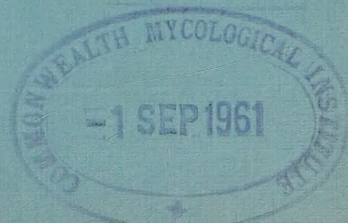


THE
Tea Research Institute
OF
Ceylon

Annual Report for the Year
1960



Published by
THE TEA RESEARCH INSTITUTE OF CEYLON
ST. COOMBS, TALAWAKELE, CEYLON,
1961



The Tea Research Institute of Ceylon

Staff as at 31st December 1960

Director	.. D. L. Gunn, C.B.E., D.Sc. (Wales), Ph.D. (Birm.)
<u>Agricultural Chemistry</u>	
Agricultural Chemist	.. J. A. H. Tolhurst, B.Sc. (Reading)
Research Assistant	.. <i>Vacant</i>
Senior Technical Assistant	.. V. Mendis
Assistants	.. S. Samarasingham
	.. T. C. Z. Jayman
	.. E. O. Stuart
	.. A. H. R. Balthazaar
<u>Biochemistry</u>	
Biochemist	.. <i>Vacant</i>
Research Assistant	.. M. S. Ramaswamy, B.Sc. (Mysore), A.R.I.C., A.I.I. Sc.
Assistants	.. T. S. Nathan
	.. B. P. M. Perera
<u>Technology</u>	
Technologist	.. E. L. Keegel
Research Assistant	.. *D. Kirtisinghe, B.Sc. (Cey.)
Assistant	.. L. S. Weragoda
<u>Plant Physiology</u>	
Plant Physiologist	.. T. Visser, Dr Ir (Wageningen)
Vegetative Propagation Officer	.. F. H. Kehl
Research Assistant	.. K. L. D. Ameratunga, M.Sc. (Mysore)
Senior Technical Assistant	.. M. Piyasena
Assistants	.. A. C. B. Pethiyagoda
	.. S. Nagarajah, B.Sc. (Cey.)
	.. A. R. M. Hassim
	.. N. S. Rajendram, B.Sc. (Madras)
	.. D. D. Kroon
	.. H. B. Ratnayake
	.. J. I. H. Bandaranayake
	.. H. R. Solomon
<u>Plant Pathology</u>	
Plant Pathologist	.. D. Mulder, Nat. Phil. Dr (Amsterdam)
Research Assistants	.. *N. Shanmuganathan, B.Sc. (Cey.)
	.. *R. L. de Silva, B.Sc. (Cey.)
Assistants	.. W. Redlich, B.Sc. (Cey.)
	.. P. V. Arulpragasam, B.Sc. (Madras)
	.. S. Murugiah
<u>Entomology</u>	
Entomologist	.. J. E. Cranham, B.A. (Cantab), D.I.C.
Entomologist, Special Research	.. E. Judenko, Ph. D. (Cracow)
Research Assistants	.. *D. Calnaido, B.Sc. (Cey.)
	.. W. Danthanarayana, B.Sc. (Cey.)
Senior Technical Assistant	.. D. J. W. Ranaweera
Assistants	.. E. F. W. Fernando
	.. C. Shanmugam
	.. G. B. Rajapakse
	.. S. Calnaido
<u>Nematology</u>	
Nematologist	.. M. T. Hutchinson, B.Sc. Ph. D. (Rutgers)
Research Assistant	.. P. Sivapalan, B.Sc. (Cey.)
Assistants	.. *M. K. Vythilingam
	.. P. A. John
<u>Agronomy</u>	
Chief Agronomist	.. <i>Vacant</i>
<u>Statistics</u>	
Statistician	.. <i>Vacant</i>
<u>Low-Country Advisory Service</u>	
Scientific Adviser	.. A. W. R. Joachim, O.B.E., B.Sc., Ph. D. (Lond.) F.R.I.C., Dip. Agric. (Cantab)
Assistants	.. U. L. M. de Silva
	.. K. H. G. Gunapala

*Working overseas

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THIRTY-FIFTH ANNUAL REPORT OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON FOR THE YEAR 1960

Foundation.—The Tea Research Institute of Ceylon was established by Ordinance No. 12 of 1925 dated 27th October, 1925.

2. The Constitution of the Board of Control is laid down in the above Ordinance and in the following Tea Research (Amendment) Acts :—

No. 24 of 1948	dated 20th December, 1948
No. 32 of 1951	„ 1st September, 1951
No. 51 of 1953	„ 19th December, 1953
No. 20 of 1955	„ 14th April, 1955
No. 8 of 1957	„ 18th March, 1957
No. 2 of 1959	„ 21st January, 1959
No. 3 of 1959	„ 21st January, 1959

3. Action has been taken during the year to make further amendments to the Ordinance to provide for : (a) an increase in the cess ; (b) exemption from customs duty of articles imported by the Institute, as the provisions existing in the table of exemption in Schedule A of the Customs Ordinance are found to be inadequate ; (c) establishment of a Medical Aid Fund for the benefit of the staff (the proposed legislation is to legalise existing practice) ; (d) the auditing of accounts on the lines laid down for the audit of State Industrial Corporations, Section 29 of Act No. 49 of 1957 ; (e) the appointment of public officers to the staff of the Institute.

Membership of Boards and Committees

4. **The Board.**—The members of the Board on 1st January, 1960 were :—

Chairman : Mr F. Amarasuriya.

Ex-Officio Members

The Director of Agriculture (Dr M. F. Chandraratna, M.B.E.).

The Hon'ble Minister of Finance (represented by Mr H. E. Peries, O.B.E., C.C.S.), Deputy Secretary to the Treasury.

The Chairman, Planters' Association of Ceylon (Mr H. Creighton).

The Chairman, Agency Section, Planters' Association of Ceylon (Mr G. I. de Glanville).

The Chairman, Low-Country Products Association of Ceylon (Mr C. S. Samaraweera).

The Tea Controller (Mr B. Mahadeva, C.C.S.).

The Director, Tea Research Institute of Ceylon (Dr D. L. Gunn, C.B.E.).

Representing the Planters' Association of Ceylon

Mr R. C. Scott, C.B.E.

Mr N. M. Sanders

Mr W. H. W. Coultas

Representing the Agency Section, Planters' Association of Ceylon

Mr R. D. Wedd

Mr R. J. Gilmour

Mr R. M. Macintyre

Representing the Low-Country Products Association

Mr F. Amarasuriya

Mr J. L. D. Peiris

Mr Errol Jayawickreme

Representing the Smallholders

Mr D. E. Hettiarachchi, J.P., U.M.

Mr Reginald Perera

*Representative of the House of Representatives**Vacant**Secretary* : Mr H. J. Balmond*Solicitors* : Messrs Julius & Creasy*Auditors* : Messrs Ford, Rhodes, Thornton & Co.*Registered Office* : St. Coombs, Talawakele.

The following changes in membership of the Board were recorded during the year :—

Ex-Officio members :—1. Mr E. Muttukumar, J.P., Chairman, L.C.P.A. vice Mr C. S. Samaraweera with effect from 28th March. He was subsequently on leave out of the Island from 13th May to 15th July.

2. Mr A. V. Richards, Acting Director of Agriculture vice Dr M. F. Chandraratna with effect from 1st June.

3. Mr R. A. G. McMichen, Chairman, Agency Section, Planters' Association of Ceylon vice Mr G. I. de Glanville from 15th July to 6th December.

4. Mr L. F. J. Smith, Chairman, Agency Section, Planters' Association of Ceylon vice Mr R. A. G. McMichen with effect from 7th December.

Representatives of the Planters' Association of Ceylon :—Mr C. R. Webber acted for Mr W. H. W. Coultas from 23rd May to 20th November.

Mr N. M. Sanders was on leave from 15th to 31st August.

Representatives of the Agency Section, Planters' Association of Ceylon :—Mr R. M. Macintyre was on four months' leave from 31st July.

Representative of the House of Representatives.—Mr J. D. Weerasekera, M.P. with effect from 6th August.

Representatives of the Low-Country Products Association.—Mr F. Amarasuriya was renominated for a further period of 3 years with effect from 19th December.

Messrs M. P. Amarasuriya and H. R. Fernando were nominated vice Messrs Errol Jayawickreme and J. L. D. Peiris as from 19th December.

Representatives of the Smallholders.—Mr D. E. Hettiarachchi was on leave out of the Island from 1st October to 25th October.

Director.—Dr D. L. Gunn, C.B.E., Director, Tea Research Institute, was on annual leave from 17th October to 28th November. Dr A. W. R. Joachim, O.B.E., Low-Country Adviser, acted as Director during this period.

Meetings.—Five meetings of the Board were held during the year on 4th March, 3rd June, 8th July, 2nd September, and 2nd December.

5. Administrative Committee.—The members of the Administrative Committee on 1st January, 1960 were :—

The Chairman, T. R. I. (Mr F. Amarasuriya), Messrs B. Mahadeva, C.C.S. (Tea Controller), R. D. Wedd, C. Selwyn Samaraweera, R. J. Gilmour, J. L. D. Peiris, W. H. W. Coultas and Dr D. L. Gunn, C.B.E., (Director, T.R.I.), Secretary—Mr H. J. Balmond.

The following changes in membership occurred during the year :—

Mr E. Muttukumaru, J.P. vice Mr C. S. Samaraweera with effect from 28th March.

Mr N. M. Sanders acted for Mr W. H. W. Coultas for the period of the latter's absence from the Island on leave from 13th May to 20th November.

Mr R. M. Macintyre vice Mr J. L. D. Peiris with effect from 19th December.

Dr A. W. R. Joachim, O.B.E., Acting Director, T.R.I. vice Dr D. L. Gunn, C.B.E., from 17th October to 28th November.

Meetings.—Five meetings of the Committee were held on 13th February, 22nd April, 9th May, 22nd July, and 21st November.

6. Experimental and Estate Committee.—The members of the Experimental and Estate Committee on 1st January, 1960 were :—

Chairman, the Director, T.R.I. (Dr D. L. Gunn, C.B.E.), Mr F. Amarasuriya (Chairman, T.R.I.), Mr G. I. de Glanville (Chairman, Agency Section, Planters' Association of Ceylon), the Visiting Agent, St. Coombs Estate (Mr Alexander Mackie), the Chairman, Planters' Association of Ceylon (Mr H. Creighton), the Visiting Agent, Low-Country Estate (Mr R. J. S. Bean), the Superintendent, St. Coombs Estate (Mr A. L. Elias), Messrs R. C. Scott, C.B.E. D. E. Hettiarachchi, A. E. A. Wallace-Tarry, S. P. Vytilingam, R. L. Harvey, E. N. Whitfield, A. Watt, W. H. W. Coultas, J. E. Davidson, P. S. Gray, A. J. Pelly-Fry and the senior scientists of the Institute.

The following changes in membership occurred during the year :—

Mr R. A. G. McMichen, Chairman, Agency Section, Planters' Association of Ceylon, vice Mr G. I. de Glanville, with effect from 15th July.

Mr R. D. Wedd representing the Chairman, Agency Section, Planters' Association of Ceylon, vice Mr R. A. G. McMichen, with effect from 7th December.

Mr R. J. S. Bean was on leave from 7th September for five months.

Mr A. E. A. Wallace-Tarry was on leave from 1st March to 8th October.

Mr C. R. Burnet vice Mr J. E. Davidson with effect from 7th February.

Mr H. D. Ross acted for Mr A. Watt from 16th March to 19th July.

Mr A. J. Pelly-Fry was on leave from 1st January to 22nd June. Mr A. D. Neale acted for him during this period.

Mr N. M. Sanders acted for Mr W. H. W. Coultas during the latter's absence on leave from 13th May to 20th November.

Meetings.—The Committee met on 6th February, 7th May, 5th August, and 15th October.

7. Appointments Committee.—The members of the Appointments Committee as at 1st January, 1960 were :—

The Chairman, T.R.I. (Mr F. Amarasuriya), Mr B. Mahadeva, C.C.S., Dr M. F. Chandraratna, M.B.E., Mr N. M. Sanders, Mr G. I. de Glanville, Dr D. L. Gunn, C.B.E. (Director, T.R.I.), Dr E. D. C. Baptiste, (Director, Rubber Research Institute, co-opted for Senior Staff appointments) and Mr H. J. Balmond (Secretary).

The following changes in membership occurred during the year :—

Mr A. V. Richards (Acting Director of Agriculture) vice Dr M. F. Chandraratna with effect from 1st June.

Mr R. D. Wedd vice Mr G. I. de Glanville with effect from 15th July.

Dr A. W. R. Joachim, O.B.E., Low-Country Adviser and Dr S. T. Seneviratne, Lecturer in Agriculture, University of Ceylon, were co-opted to the Committee for special appointments.

Meetings.—Two meetings were held on March 26th and 21st July.

8. Buildings Committee.—The members of the Buildings Committee on 1st January, 1960 were :—

Mr W. H. W. Coultas (Chairman), Mr F. Amarasuriya (Chairman, T.R.I.) Mr J. L. D. Peiris, Dr D. L. Gunn, C.B.E. (Director, T.R.I.) and Mr H. J. Balmond (Secretary).

Mr N. M. Sanders acted for Mr W. H. W. Coultas as Chairman of the Buildings Committee during the latter's absence on leave out of the Island from 13th May to 20th November.

The Buildings Committee held three Committee Meetings and in addition twelve conferences with the Contractors and Architects.

9. Low-Country Sub-Committee.—The members of the Committee on 1st January, 1960 were :—

The Chairman (Mr F. Amarasuriya), Messrs J. L. D. Peiris, Errol Jayawickreme, H. Creighton, the Director, (Dr D. L. Gunn, C.B.E.), Messrs R. J. S. Bean, A. Watt (Co-opted members) and Dr A. W. R. Joachim, O.B.E., Convener.

The following changes in membership occurred during the year :—

Mr D. E. Hettiarachchi vice Mr J. L. D. Peiris with effect from 19th December.

Messrs J. L. D. Peiris and Errol Jayawickreme were co-opted as members of the Committee with effect from 19th December.

Meetings.—Four meetings of the Committee were held on 16th January, 12th February, 19th May and 17th October.

10. Scientific Advisory Committee in the United Kingdom.—The Committee started functioning on 1st January, 1960.

The members of the Committee are :—

Dr F. R. Tubbs, C.B.E., Director of East Malling Research Station (Chairman); Professor G. E. Blackman, F.R.S., Sibthorpe Professor of Rural Economy, Oxford; Mr F. C. Bawden, F.R.S., Director of Rothamsted Experimental Station; and Professor T. A. Bennet-Clark, F.R.S., Professor of Botany, King's College, London.

The Committee held two meetings on 24th February and 17th November.

Dr Tubbs visited the Island and toured extensively from 26th June to 5th August.

Professor G. E. Blackman visited the Institute from the 11th to 18th September.

Dr D. L. Gunn (Director) attended the meeting of the Committee held on 17th November.

11. Trustees of the Tea Research Institute of Ceylon Junior Staff Provident Fund.—The Chairman, T.R.I. (Mr F. Amarasuriya), the Director, T.R.I. (Dr D. L. Gunn, C.B.E.), Messrs. R. J. Gilmour and D. E. Hettiarachchi, J.P., U.M.

Mr R. I. Pereira was nominated by the Junior Staff as their representative with effect from 9th August.

12. Committee of Management, Tea Research Institute of Ceylon Junior Staff Medical Fund.—The Chairman, T.R.I. (Mr F. Amarasuriya), the Director, T.R.I. (Dr D. L. Gunn, C.B.E.).

Mr W. P. Chandrasekera was elected as the Junior Staff's representative with effect from 9th August.

13. Other Committees:—The Board appointed the following *ad hoc* Sub-Committees during the year :—

(a) **The Provident Fund Sub-Committee.**—Appointed on 4th March to examine and report on existing Provident Fund superannuation benefits to staff. The members are :—

The Chairman (Mr F. Amarasuriya), Messrs G. I. de Glanville (Chairman, Agency Section), B. Mahadeva, C.C.S., R. D. Wedd, W. H. W. Coultas, R. J. Gilmour, H. E. Peries, O.B.E. C.C.S., (Deputy Secretary to the Treasury), Dr D. L. Gunn, C.B.E. (Director, T.R.I.) and Mr H. J. Balmond (Secretary).

Mr N. H. W. Wykeham-Dulling, Secretary, Planters' Association, was co-opted to the Committee.

The Committee held one meeting on 9th May, 1960.

(b) **The Economic Sub-Committee on Instant Tea.**—Appointed on 3rd June, 1960, to examine and take action on the economic and business issues arising from the development of Instant Tea as a commercial product. The members are :—

Mr F. Amarasuriya (Chairman), Mr R. J. Gilmour, Mr B. Mahadeva, C.C.S. (Tea Controller), Mr H. E. Peries, C.C.S., O.B.E. (Deputy Secretary to the Treasury), Mr V. L. Wirasinha, C.C.S., (Director of Commerce), Mr W. H. W. Coultas, Dr D. L. Gunn, C.B.E. (Director, T.R.I.) and Mr H. J. Balmond (Secretary).

Mr N. M. Sanders acted for Mr W. H. W. Coultas from 13th May to 20th November.

Two meetings were held on 14th June and 12th September.

The Committee interviewed the Hon'ble Minister of Commerce on 11th October, 1960.

(c) **Salaries Sub-Committee.**—Appointed on 2nd September and the members were :—

The Chairman, T.R.I. (Mr F. Amarasuriya), Chairman, Agency Section (Mr R. A. G. McMichen), Chairman, Low-Country Products Association (Mr E. Muttukumar), Messrs R. J. Gilmour, J. L. D. Peiris, Dr D. L. Gunn (Director, T.R.I.) and H. J. Balmond (Secretary).

Mr D. E. Hettiarachchi replaced Mr J. L. D. Peiris with effect from 18th December and Mr L. F. J. Smith replaced Mr R. A. G. McMichen as from 7th December.

14. Visiting Agent.—Mr Alexander Mackie continued as the Visiting Agent for St. Coombs Estate. He visited the estate on 25th April, 18th August and 19th December.

15. Finance.—Income for the year which totalled Rs. 2,621,654 exceeded that of the previous year by Rs. 149,666. Receipts from the cess exceeded the previous year's figures by Rs. 145,019 and revenue profit from St. Coombs estate by Rs. 10,810. Other sources of income, viz. Interest Rs. 79,482, Rent of Caddy Rs. 1,800, Profit on sale of Fixed Asset Rs. 7,272, Sale of Clonal Cuttings Rs. 10,336 and Miscellaneous Receipts Rs. 2,085 totalled Rs. 100,975 as against Rs. 107,138 in 1959.

Revenue expenditure (excluding depreciation) amounted to Rs. 2,277,989 as compared with Rs. 1,988,907 in the previous year. The increase in expenditure was made up chiefly by two items viz. Emoluments of Staff by Rs. 124,219 and Field and Factory Experiments by Rs. 108,891. Other items which recorded increased expenditure were Travelling of Staff, Rs. 22,946, Maintenance of Buildings Rs. 36,391, General Services Rs. 33,925, Laboratory and General Working Expenses Rs. 10,807 and Miscellaneous Rs. 12,825. Against these items expenditure on Library and Publications, and Depreciation on Investments was less by Rs. 20,950 and 3,849 respectively. Capital expenditure totalled Rs. 1,259,890 as compared with Rs. 480,139 in 1959. Main heads of expenditure were Buildings Rs. 462,607, Vehicles Rs. 25,832, Furniture and Equipment Rs. 136,700, Land and development Rs. 127,868, Laboratory equipment Rs. 66,018. Accumulated depreciation as at 31st December, 1960, was Rs. 2,053,925 with Liquid Assets amounting to Rs. 3,467,980 and Liabilities to Rs. 836,488. Against this there is a committed expenditure as at 31st December, 1960 of Rs. 1,518,737 on new buildings including 17 Junior Staff houses, the extension to the headquarters buildings, and the water supply.

Acknowledgments.—The Board records its thanks to the Ceylon Association in London, the Planters' Association of Ceylon, the Agency Section of the Planters' Association of Ceylon, the Low-Country Products Association and other institutions for their continued support and co-operation in matters concerning the Institute and the Tea Industry in Ceylon.

The Board also extends its thanks to the Planters' Association of Ceylon, the Tea Controller, and the Director of the Ceylon Institute of Scientific and Industrial Research, for having placed their meeting rooms at its disposal.

Auditors.—Messrs Ford, Rhodes, Thornton & Co., continued to act as the Institute's Auditors. The Audited Statement of Accounts and the Balance Sheet for the year ending 31st December, 1960, are attached to this report.

H. J. BALMOND,
Secretary.

TEA RESEARCH INSTITUTE OF CEYLON

BALANCE SHEET AS AT 31st DECEMBER 1960

ACCUMULATED FUND	1960 Rs.	1959 Rs.
<i>Expended on Fixed Assets:</i>		
Balance at 31.12.1959	5,872,049	
Additions less disposals	<u>1,171,888</u>	
	7,043,937	
<i>Unexpended Fund</i>		
Balance at 31.12.1959	1,709,554	5,872,049
Less: Adjustment during the year	<u>36,075</u>	
	1,673,479	
Less Additions to Fixed Assets less disposals during the year	1,171,888	1,820,175
	<u>501,591</u>	<u>4,051,874</u>
Add Excess of income over expenditure	75,977	577,568
	7,581,603	7,621,505
CREDITORS AND PROVISIONS	207,081	709,630
PROVISION FOR FURLOUGH PAY AND PASSAGES	96,486	126,858
	<u>8,457,993</u>	<u>7,885,170</u>

We have examined the above balance sheet with the books of the Tea Research Institute of Ceylon and Sr Coombs Estate and have obtained all the information and explanations we have required. In our opinion the foregoing balance-sheet is properly drawn up so as to exhibit a true and correct view of the financial affairs of the Institute as at 31st December, 1960, according to the best of our information and the explanations given to us and as shown by the books.

Colombo, 15th April, 1961.

(Signed) FORD, RHODES, THORNTON & CO.,
Chartered Accountants.

TEA RESEARCH INSTITUTE OF CEYLON

ESTATE WORKING ACCOUNT FOR THE YEAR ENDED 31st DECEMBER 1960

1959 Rs.	ESTATE REVENUE EXPENDITURE	Rs.	1960 Rs.	1959 Rs.	TEA SALES—GROSS PROCEEDS	Rs.	1960 Rs.
114,829	General Charges	125,983			Colombo	305,644 lb	851,137
78,540	Up-keep	70,022			Local B.O.P.	3,119 "	6,088
50,831	Cultivation	53,993			Local B.M.	11,392 "	8,373
117,827	Harvesting	113,026			Biochemical Dept.	366 "	914
105,292	Manufacture	116,134	479,158	778,218	Gratis	2,811 "	—
467,319						323,332	866,512
11,779	Colombo Brokerage & Handling Charges	13,236					
70,325	Ad. Valorem Tax	132,154		27,249	Sales of Clonal Cuttings		24,952
71	Debit tax—on Sales Tax	133					
253,973	Balance to Income & Expenditure A/c.	266,783					

805,467	891,464	805,467	891,464
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TEA RESEARCH INSTITUTE OF CEYLON

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st DECEMBER 1960

186,808	Administration	260,936	255,973	Balance from Estate Working A/c.	266,783
434,043	Senior Scientific Staff	446,727	2,108,877	Tea Cess	2,251,896
54,354	Laboratory	62,161	82,901	Interest	79,482
76,397	Intermediate Scientific Staff	86,646	1,800	Rent of Caddy	1,800
184,489	Junior Scientific Staff- Minor Employees	229,629	1,099	Miscellaneous Receipts	2,085
39,976	Library and Publications	19,026	11,500	Tea Replanting Subsidy	—
209,478	Field and Factory Experiments	318,369	2,250	Profit on sales of investments	—
92,184	Travelling of Staff	115,130	7,588	Profit on sale of fixed assets	7,272
43,566	Engineering Dept.	46,627	—	Clonal cuttings account	10,336
41,993	Maintenance of buildings	78,384			
148,139	General services	182,064			
41,730	Miscellaneous	54,555			
350,000	Small Holdings Advisory Service	350,000			
255,594	Depreciation	267,688			
10,467	Depreciation on investments	6,618			
75,283	Junior Staff Provident Fund	—			
—	Scholarship expenses	6,609			
—	Lab.-Country Sub-station	11,508			
227,487	Balance of Income over Expenditure	75,977			
<u>2,471,988</u>		<u>2,621,654</u>	<u>2,471,988</u>		<u>2,621,654</u>

REPORT OF THE DIRECTOR FOR 1960

D. L. Gunn, C.B.E., D.Sc.

Staff

The year was exceptional in having neither losses nor gains in numbers of senior staff, but arrangements were made for two additions to become effective in 1961. The Intermediate Grade gained two and lost two (one on 31st December), leaving vacancies in most divisions by the new year. The filling of these vacancies with good men or women depends on successful buying in a sellers' market. In the Junior Staff there were four losses and eleven gains, but this included three extra staff in the office to comply with new regulations regarding overtime, and the nett gain in the scientific divisions was three.

Two more Intermediate Grade officers went overseas for further training, making four in all, and two more junior officers, making three altogether, one of whom returned about the end of the year.

Buildings

During the year, nine houses were completed and were mostly occupied before the decorations could be done. These houses consisted of one family house and a small semi-detached pair for senior officers, two houses for Intermediate Grade families, and four for junior officers' families. Over-crowding hardly diminished among the juniors, several being accommodated off the estate, and contracts for 17 more houses for them were being negotiated at the end of the year. More houses for all grades of staff were planned for 1961 and also an extension to the headquarters building. This extension is to accommodate an enlarged library and expanded research on biochemistry and development of manufacture ; it will also take the administration and thus leave room for expanding especially the Advisory Division in the old building.

The new filter system for the water supply was well advanced by the end of the year. A new caddai was completed.

Outlying Stations

Investigations and negotiations regarding the purchase of suitable tea land for a low-country sub-station continued actively during the whole year and there were, at the end of the year, firm grounds for hope of success. A clonal-testing station was opened on crown land at Kottawa, near Galle, and another, with the cordial co-operation of the owners, on Hantane Estate in the mid-country. The testing station at Neuchatel was closed, having served its purpose and having provided very many clonal cuttings.

Visitors

Two members of the Scientific Advisory Committee in the U.K. (SACUK) visited the Institute. Dr F. R. Tubbs, the Convener and Chairman, who had just been honoured by appointment as C.B.E., arrived in late June and renewed his knowledge of the tea industry in Ceylon, touring and discussing problems for about six weeks. Professor G. E. Blackman, F.R.S., spent a week in the Island on his way to Malaya and further east. There were many visits by planters and members of all sections of the industry in Ceylon and overseas.

Research

Since the end of the first world war, the production of tea in Ceylon has risen steadily and fast, with only minor aberrations, presumably due to weather. In the last 15 years, the rise has averaged 11.09 million pounds per annum, as determined by regression fitting of a simple-interest straight line. Using a compound-interest curve, the rate of rise is 3.08% per annum. In spite of the many variables involved, both lines fit well, the compound-interest one slightly the better, and only in one year (1952) was the production of tea substantially divergent.

One may therefore extrapolate into the future for a few years, if no large new factor enters the situation. On this basis (compound interest), the regression point for total production for 1960 would be 431 million pounds instead of 435 and forecasts for 1961 etc. would be 444, 458, 472, 486 and 501 (1965) million pounds. If this rate of increase could be maintained, the production of tea would keep ahead of the population rise in Ceylon that is officially forecast. It is, however, doubtful if such annual increases can be sustained for much longer without new methods and the primary task seems to be to apply and discover new methods, so that ceilings of production are not reached.

The importance of high production is two fold : it tends to increase gross income (if prices hold up) both for the estate and for the Island ; and it spreads overheads so that it tends to reduce cost of production per pound and so to improve the competitive position. Either increased gross income or decreased C.O.P. may occur without the other and it is naturally most desirable to have both. Since most of the margin between cost of production and gross proceed of sale goes in taxes, improvements in production have to be very large before they provide much incentive in terms of dividends.

The other side of the picture is selling price which, over the last decade, does not seem to have risen as much for tea as world levels of prices in general. It has been suggested that the machinery for limiting production should be kept in readiness, in case this situation continues. In addition, the competitive position of Ceylon may be improved by raising quality and the market for tea may be more rapidly enlarged than it is being at present.

As will be seen from the research reports that follow, these matters are very much in the minds of the research workers in the T.R.I. A practical application which could even accelerate the rise in production is replanting with vegetatively propagated material. By the end of 1960 subsidized V.P. had hardly covered 1,200 acres, with about 2,000 acres more uprooted in preparation, out of about 450,000 acres under tea on estates of over 100 acres. This cannot increase production until the tea comes into bearing in some years' time and it is too small a proportion of the whole to affect it much even then. There is ample good-quality clonal material to replant very much faster than has yet been done and there is a long way to go before the few very popular clones constitute a significant proportion of the tea in the Island. In 1960, St. Coombs Estate alone sold $1\frac{1}{4}$ million cuttings, enough for 200 acres of planting, while at least one commercial estate is capable of supplying many times that number: clonal material is not the difficulty. The problem is one of financial confidence. Unless the confidence of the entrepreneur in the financial future is stimulated, it seems likely that the decline in the rate of replanting will continue.

The rational view is being taken in the T.R.I., and every effort is being made to test clones, discover still better ones, and encourage planters to make a start, so that at least they become familiar with techniques and establish their own mother bushes.

Nobody can say how long tea production in Ceylon can continue to be raised by cultural and defensive improvements on the existing bushes ; it may not be for very much longer. Once the existing bushes reach their ceiling, a programme of uprooting them and replanting with high-quality clones would reduce total production for perhaps ten years. If such a reduction in crop, with all its consequences to companies and country, is to be prevented, replanting should be accelerated now, under the shelter of rising crops.

An improvement which might raise crops dramatically in the next few years is control of Shot-hole Borer in the mid-country. Little is yet known of the effect on yield of the control method now being tested on selected estates, but there is a general feeling that it might amount to a couple of hundred pounds per acre per annum. If that is realised, it might be sufficient to jerk some mid-country estates out of their depression, enable replanting there to accelerate, and make the future prospects of the region brighter.

It would be invidious to pick out from the various research reports the advances in knowledge being made. In some directions, controversy is active—the value of shade trees is being discussed in all the major tea-producing countries of the world—and it is too early even to mention some of the other lines of thought.

For another reason, little is said about the work on powder tea, instantly soluble in water. Such an instant tea can now be made in the laboratory, with some of the characteristics of an up-country liquor. Naturally details cannot be given but will be reserved for the organization which embarks on commercial manufacture. At the end of the year, it was envisaged that the greater part of the capital would be subscribed in Ceylon and that overseas enterprise would provide development and manufacturing skill and a marketing organization ; it was subsequently learned officially that governmental encouragement would be given by concessions to overseas capital. If this venture can be made successful, it may open the new markets required for the expanding crops that Ceylon is capable of supplying.

Finance

As was noted in my Annual Report for 1959, it had been agreed to increase the cess that pays for the Institute from 55 cents to 75 cents per 100 lb. of tea exported, but Parliament had not implemented this. The year 1960 saw several changes in Government and the amendment did not come before Parliament. As plans developed and work expanded, it became evident that the increase of 20 cents would not be enough and a further increase to a total of Re. 1 per 100 lb. of tea exported was agreed. At the end of 1960, there was hope that an amending act would be passed soon; in the mean time, the Institute had embarked on a one-rupee programme but still had only a 55-cent income.

The estate yielded a substantial working profit; if capital expenditure on the estate is deducted from this profit, the nett contribution made by the estate to the Institute was Rs. 116,816. This is similar to the nett contribution for 1959 but considerably less than for the previous five years, and the amount must be expected to decline steeply for the next seven years or so, because of reduction of crop and increase of capital expenditure due to replanting. This replanting is intended to provide substantial areas of mono-clonal tea for experiments. Many of the experiments cannot begin until the tea is mature about seven years after uprooting the old tea, so a large programme of 15 acres per annum (5-6% of the tea on the estate) has been begun. Examination of the records from 1950 shows an inverse relation between the amount of crop and the average cost of production per pound. On this basis, in 1964-65 with an expected crop around 200,000 lb. compared with a record of over 323,000 lb. in 1960, the C.O.P. on revenue account may rise to as much as Rs. 2 per pound

at present price-levels. Thereafter the financial situation should begin to improve as the clonal tea comes into bearing.

In 1960, the financial situation did not deteriorate as much as was feared because building payments were delayed and some senior and intermediate posts were not filled, while the record export of tea yielded a higher cess income than had been expected. For 1961, the estimates are based on a one-rupee cess, delayed payments for buildings will fall due, and arrangements have already been made to fill some of the most expensive vacant posts. In these circumstances and with the cost of opening the low-country sub-station to be repaid, it is urgently desirable for the increase in cess to be implemented, to avoid depletion of reserves on current account and on quasi-capital expenditure.

Neither the T.R.I. nor the industry in Ceylon is moving into still waters. But there are signs that still greater achievements may lie ahead.

STAFF CHANGES

Appointments

Senior Staff

No changes.

Intermediate Staff

Mr W. Danthanarayana—Research Assistant to the Entomologist, from 15th September.

Mr P. Sivapalan—Research Assistant to the Nematologist, from 26th December.

Junior Staff

Mr P. V. Arulpragasam—Technical Assistant to the Plant Pathologist, from 1st January.

Mr N. S. Rajendram—Technical Assistant to the Plant Physiologist, from 1st January.

Mr A. H. R. Balthazaar—Technical Assistant to the Agricultural Chemist, from 1st January.

Mr D. J. M. Hettiarachi—Photographer, from 1st January.

Mr S. Calnaido—Technical Assistant to the Entomologist, Special Research, from 21st June.

Mr K. H. G. Gunapala—Technical Assistant to the Low-country Scientific Adviser, from 15th September.

Mr K. M. L. B. Fernando—Assistant Electrician, from 6th January.

Mr M. B. Palies—Accounts Clerk, from 5th April.

Mr H. M. R. Bandara—Clerk/Typist, from 8th July.

Mr T. R. B. Sally—Clerk/Typist, from 11th July.

Mr S. Kulasabanathan—Clerk/Typist, from 1st August.

Overseas Training

Mr R. L. de Silva, Research Assistant to the Plant Pathologist, left on 4th September for post-graduate studies at the Imperial College of Science and Technology, London.

Mr D. Kirtisinghe, Research Assistant to the Technologist, left on 2nd September for post-graduate studies at the Imperial College of Science and Technology, London.

Mr M. K. Vythilingam, Technical Assistant to the Nematologist, left for the U.S.A. on 23rd April for training in Nematology work.

Mr L. M. de W. Tillekeratne, Senior Technical Assistant to the Chief Advisory Officer, left on 17th August for U.S.A. on a U.S.O.M. Scholarship for post-graduate studies.

Resignations

Mr R. A. Jayatilleke, Research Assistant to the Nematologist, on 31st August (Intermediate Staff).

Mr S. Karunaratne—Research Assistant to the Agricultural Chemist, on 31st December (Intermediate Staff).

Mr A. E. T. Ellawella—Technical Assistant to the Low-country Scientific Adviser, on 30th June (Junior Staff).

Mr D. C. W. T. Amerasinghe—Stenographer, on 30th June (Junior Staff).

Mr K. Sothisrihari—Technical Assistant to the Technologist, on 5th August (Junior Staff).

Mr N. de S. Jayasundere—Technical Assistant to the Plant Physiologist, on 31st December (Junior Staff).

Transfers

Mr A. C. B. Pethiyagoda from Passara Sub-Station to Hantane Sub-Station, Kandy, from 1st July.

Mr D. D. Kroon from St. Coombs to Passara Sub-Station from 15th June.

Mr H. B. Ratnayake from Neuchatel Sub-Station to Kottawa Sub-Station, Galle, from 1st May.

REPORT OF THE SUPERINTENDENT OF ST. COOMBS ESTATE FOR 1960

A. L. Elias

Staff.—A third Assistant Clerk was engaged on 15th March to deal with the large volume of work connected with the sale of V. P. cuttings and the Employees' Provident Fund. An additional single-session school teacher was engaged on 1st January. The work of all members of the subordinate staff throughout the year was extremely satisfactory.

Acreage as at 31st December, 1960.

			A.	R.	P.
Tea in full bearing	..	..	226	3	0.00
Tea under experiments (plucking only)	..	..	18	0	0.00
New Clearing Field No. 1					
1955/56 planting	..	..	8	3	21.29
1959 planting	..	..	7	1	17.12
1960 planting	..	..	2	0	1.00
Guatemala grass clearing	..	..	8	0	0.00
Llan Thomas & 14B—1961 planting	..	..	10	0	0.00
Areas under rehabilitation					
Field No. 7	..	..	6	2	0.00
Field No. 8	..	..	16	2	0.00
Nurseries Nos. 1, 12, New V.P. Nursery			2	0	0.00
Fuel Clearings, etc.	..	..	22	2	2.00
Buildings, roads, gardens, etc.	..	..	59	2	14.00
Land unsuitable for planting	..	..	32	2	21.59
Area reserved for clonal cuttings	..	..	3	1	0.00
			423	3	37.00

During the year tea was uprooted on 12 acres in Field No. 8 and $6\frac{1}{2}$ acres in Field No. 7 for replanting purposes. After approximately 18 months rehabilitation under Guatemala grass, these areas will be planted in April/June 1962.

A re-survey of the estate which was to have been carried out in 1960 was postponed.

Weather.—(Estate Gauge).—

		Rainfall inches	Wet days	Sunshine hours
Registered in 1960	..	106.48	250	1,686
Registered in 1959	..	92.80	212	1,996
Registered in 1958	..	80.08	229	1,842
Registered in 1957	..	97.72	221	1,992
Decennial averages (1950-1959)	..	90.55	227	1,844

Rainfall was well distributed and even throughout the year and no serious drought was experienced.

Rainfall recorded in the first three months was 15.93"—41 wet days, *i.e.* January 3.69"—14 wet days, February 8.40"—17 wet days and March 3.84"—10 wet days.

Weather conditions in February were unusual. The first week remained dry, thereafter what appeared to be intermonsoonal showers fell during the rest of the month, mostly in the late afternoons. Two heavy falls of 1.03" on the 10th and 1.79" on the 15th were recorded and the total rainfall for the month was the highest in any February since 1929.

Light mist was in evidence during the first three months of the year, but no frost was experienced. Except for strong gusty winds, sometimes of gale force, the south-west monsoon was much less severe than in 1959. Rainfall recorded during this period was April 9.87"—20 wet days, May 10.25"—29 wet days, June 8.78"—25 wet days, July 10.71"—31 wet days and August 7.87"—22 wet days. September was a particularly bad month and for the first time during the year, really adverse weather conditions were experienced mostly during the latter half of the month. Short dry spells were experienced in November and December and heavy mist was seen to settle in low-lying areas and hollows. The total recorded rainfall for the year was 106.48" which was 15.93" above the decennial average. There were 250 wet days. The heaviest fall for the year was 2.74" which fell on 14th April.

Crop.—

	1960 lb.	1959 lb.	1958 lb.
Estimate	270,000	270,000	270,000
Total crop (including off grades)	323,331	280,150	320,080
Yield per acre on 251½ acres ..	1,286	—	—
Yield per acre on 260½ acres ..	—	1,060	—
Yield per acre on 265¾ acres ..	—	—	1,204

The estimated crop of 270,000 lb. of made tea was exceeded by 53,331 lb. and the yield per acre for the year was 1,286 lb. This constitutes an all-time record for St. Coombs. The previous best crop harvested was 320,080 lb. which was obtained in 1958 with a yield of 1,204 lb. per acre. A notable feature was the even monthly intake of crop throughout the year as follows :—

Month	Made Tea lb.	Yield per acre
January	30,622	117
February	25,351	98
March	33,970	131
April	34,580	133
May	32,499	127
June	21,738	90
July	18,292	75
August	25,515	104
September	19,405	79
October	17,630	72
November	37,390	152
December	26,339	108
	<u>323,331</u>	<u>1,286 lb.</u>

The only poor-cropping months were July and October. The highest crop for the year was harvested in November, when the average yield for the estate was 152 lb. per acre. Cash plucking and Sunday plucking had to be resorted to on a few occasions. The quality of leaf brought into the factory was good throughout and all teas fetched reasonably good prices.

Prices and Total Crop Sold.—

Year	Total Crop sold lb.	Total price cents	Nett price cents
1960	320,521	270	225
1959	277,790	281	250
1958	317,956	297	293

Prices fetched for St. Coombs teas at Colombo auctions (305,644 lb.), as distinct from those sold locally, were 278 cents (gross) and 231 cents (nett) which compared favourably with the high-grown average and with those of neighbouring estates and were often very near the top of the Colombo market. The nett sale average, however, has fallen below those of the previous two years. The chief reason for this was the failure of the Dimbula flavoury season in January/February this year.

The best invoices were :

Invoice No.	Month	Rs. per lb.
7	February	4.40
8	March	4.20
9	March	4.50

Cost of Production.—

	1960 Cost per lb. cents	1959 Cost per lb. cents	1958 Cost per lb. cents
Estimate	173	180	175
Actual	148	167	153

Profit on Estate Working.—

1960	..	Rs.	266,783
1959	..	„	255,973
1958	..	„	418,724

Capital Expenditure.—

1960	..	Rs.	149,967	47 cents per lb.
1959	..	„	140,823	50 cents per lb.
1958	..	„	152,854	48 cents per lb.

The main items of capital expenditure were :

	Rs.
New Nursery	11,177
Buildings	53,037
New Clearings	
Area planted prior to 1957 ..	7,868
1959 planting	6,686
1960 planting	7,178
1961 planting	5,371
1962 planting	25,123
Ravines to be cleared	8,663
Factory	14,298
Furniture	4,931
Playground	5,635

Plucking.—7-8 day plucking rounds were maintained throughout the year and the standard of leaf harvested was always of a fairly high quality. The plucking-incentive system of fixing a datum each day for each field has continued to prove satisfactory, though it did not completely eliminate the need for cash plucking after normal hours nor the need to pluck on Sundays. The average per plucker for the year was 27 lb. compared with 25 lb. in 1959 and 28 lb. in 1958.

Estate Roads and Paths.—The usual routine maintenance of all field roads, footpaths and estate roads was carried out. Terracing of side drains was done where necessary. The road leading to the new nursery was consolidated and side drains and culverts built. Further consolidation of the road through Field No. 4 was also done.

Fuel Clearings.—Only routine maintenance work was done during the year. Drains in the marsh below Field No. 14B were deepened and gum plants supplied. The main drain leading out of the estate through Kowlahena Estate, to the river, was cleaned throughout its length. So were all drains flowing into this leader drain. Firewood was plentiful and the demands of all estate and Institute Staff were met.

Ravines and Boundaries.—All boundaries are in good order and only routine maintenance was carried out. Regular checks for cootch were made throughout the year. Many small ravines were reclaimed during the year and were planted up with Guatemala grass or mana grass.

Weeding.—The over-all cost of weeding for the year was Rs. 29,204, or Rs. 9/98 per acre. Weeding contracts continued to be popular with labourers. A regular monthly round was maintained throughout the year. Due to up-rooting, the area weeded on contract and the area weeded on estate account varied as follows :

Month	Total acreage weeded for the month	Contract acres	Estate acres
January ..	265 $\frac{3}{4}$	181 $\frac{1}{4}$	84 $\frac{1}{2}$
February ..	265 $\frac{1}{2}$	190 $\frac{1}{4}$	75 $\frac{1}{4}$
March ..	265 $\frac{1}{2}$	190 $\frac{1}{4}$	75 $\frac{1}{4}$
April ..	265 $\frac{1}{4}$	190	75 $\frac{1}{4}$
May ..	248 $\frac{3}{4}$	170 $\frac{1}{4}$	78 $\frac{1}{2}$
June ..	232 $\frac{3}{4}$	149 $\frac{3}{4}$	83
July ..	232 $\frac{1}{4}$	163 $\frac{3}{4}$	68 $\frac{1}{2}$
August ..	229 $\frac{3}{4}$	160 $\frac{1}{4}$	69 $\frac{1}{2}$
September ..	229 $\frac{3}{4}$	146 $\frac{3}{4}$	83
October ..	229 $\frac{3}{4}$	142	87 $\frac{3}{4}$
November ..	229 $\frac{3}{4}$	138	91 $\frac{3}{4}$
December ..	229 $\frac{3}{4}$	137	92 $\frac{3}{4}$
	2,924 $\frac{1}{2}$	1,959 $\frac{1}{2}$	965

All weeds were transported to centrally situated compost sheds and turned into compost by the Indore method. Except for occasional prolific weed growth, weeds presented no real problem. Altogether 130 tons of compost were made during the year.

Pests and Diseases.—**Blister Blight**—Spraying against Blister Blight continued periodically throughout the year whenever weather conditions favoured this pest. A few serious large-scale attacks were anticipated and adequate precautions were immediately taken by increasing the dosage from 4 ozs. to 8 ozs.

of copper fungicide per acre. Localized attacks of some severity were noticed in certain susceptible areas which are demarcated and receive special attention. Pruned fields also continued to receive careful attention during the time of recovery from pruning.

Several makes of motorised knapsack mist-blowers were tried out from May onwards and proved to be extremely effective in tea for spraying copper fungicides for the control of Blister Blight. Much lower volumes of water per acre were used, namely 4—6 ozs. of copper fungicide in two gallons of water per acre. Costs were also found to be considerably lower in comparison with conventional high-volume knapsack spraying.

Scarlet and Yellow Mites.—There was very little evidence of attack from these pests. Provision was made for protection but the mild attacks in susceptible areas did not justify the use of any insecticide.

White Grub—A severe attack by white grub in the new V. P. nursery was immediately checked by the timely application of an insecticide with the co-operation of the Entomologist and his staff.

Poria.—Some *Poria* patches were noticed in Field No. 3. In view of the fact that this field is due for uprooting in 1963 these patches have been adequately isolated and special attention will be given to these areas prior to uprooting.

Pruning.—The following fields were pruned during the months indicated against each field :

No. 5—20 acres—May

No. 10—2 acres—July (1952 clonal area)

No. 13—21 acres—June to mid July

A light clean prune was adopted, taking out knotted and whippy branches. All pruning and tipping was done on the slope and recovery generally was good all over. Pruning commenced on the 21st of April, and fields Nos. 5 (20 acres), 13 (21 acres), and No. 10—1952 clonal area (2 acres) were pruned in that order. Due to uprooting, Field No. 7 (13 acres), a part of which was uprooted this year ($6\frac{1}{2}$ acres) was not pruned. The balance area of $6\frac{1}{2}$ acres due for uprooting in 1961 was lightly cut across.

Supplying and Nurseries.—The nurseries in Fields Nos. 1 and 12 were handed over to the Nematology Division at the beginning of the year for experimental purposes.

The new V. P. nursery in the gum clearing adjoining Field No. 14A was completed and holds 150,000 plants comprising the following clones :

Clone No.	No. of Plants
2024	70,000
2025	26,000
777	50,000
UPR (Marker clone)	4,000

Cuttings were planted out in March in pilot plots using three clones, namely TRI 2024, TRI 2025 and TRI 2026 and three types of soil, *i.e.* (a) half-inch sub-soil and tea fluff, (b) six inches sub-soil and tea fluff, (c) existing nursery soil. Assessments of growth to date showed that the best results were obtained in all plots where 6" of sub-soil and tea fluff were used, regardless of

the clone. The mixture used was one part of tea fluff to five parts of sub-soil by volume. The mixture was broken down before use. Subsequently, cuttings were planted in beds, baskets and polythene cylinders and results have been extremely satisfactory. Several methods were tried out, namely (a) cuttings in beds for direct planting in the field, (b) a single cutting direct in each basket and polythene cylinder, (c) two cuttings direct in each basket and polythene cylinder, (d) various sizes of baskets and polythene cylinders were also used. Results from all these methods have proved satisfactory, particularly where cuttings were planted direct in polythene cylinders. In the case of TRI 777, some of the mother bushes were sprayed with urea at an application rate of 6 lb. per application per acre at 1 lb. per 10 gallons of water prior to taking cuttings. Results to date have been encouraging. Urea contains 46% nitrogen and is a foliar nutrient. This treatment induces axillary bud development and cuttings planted in this way tend to root more quickly. This is an advantage with TRI 777, which is known to be a poor rooter, and will apply to other clones which are known to be poor rooters. Manuring of all plants in this nursery commenced eight weeks after planting and very light applications were given at fortnightly intervals using Starter Mixture No. 1, Sterameal 'A' and T. 175. The last was watered on. Regular thinning out of shade was done from time to time wherever fern was used. Woven coir matting (1/8" diameter holes) was also used to a large extent and was found to be excellent.

Mossing and Ferning.—All pruned fields were treated with "Limbox" to control moss and lichen at $1\frac{1}{2}$ cwt. per acre, using Birchmeir Senior Sprayers with No. 2 lime-washing jets. Ferns were removed by weeding contractors and this method was found to be successful, provided close supervision was given. Moss, lichen and ferns are well controlled. Ferns are removed monthly by weeding contractors and present no serious problem.

Manuring.—The practice of applying the T.488 mixture at six-monthly intervals or when a field has yielded between 450 and 500 lb. of made tea per acre since the last application of manure, whichever is the earlier, was discontinued at the beginning of the year. In accordance with the Visiting Agent's recommendation contained in his report dated 23rd December 1959, following his visit to St. Coombs on 21st December 1959, the programme was altered as follows: all fields receive three applications of T.500 mixture per annum, except in the year when they are pruned. Fields in the year when they are pruned receive two applications at the rate of 40 lb. of nitrogen, one four months before pruning and one approximately four months after pruning. For the rest of the cycle, fields receive further applications at intervals of four months on a growth basis of 10 lb. of nitrogen for every 100 lb. of made tea harvested since the previous application. The application rate should never fall below 35 lb. of nitrogen, even though the amount of crop harvested in the previous four months may be less than justifies this figure. All pruned fields receive one deep forking in every alternate row during the first and second applications of manure, following the recommendation that every field should receive at least one deep forking in the cycle. Broadcasting was done at all other times. The 1952 clonal area in Field No. 10 (pruned this year) received four applications of T.500 mixture at the rate of an average of 44 lb. of nitrogen per application. The 1954 clonal area received four applications of T.500 mixture at the rate of $1\frac{1}{4}$ ozs. per plant per application.

The following fields received one application of dolomite against possible magnesium deficiency:

Field No.	5—20	acres	
" "	7—	$6\frac{1}{2}$	"
" "	10—	2	" (clonal area)
" "	13—	21	"

Top dressings of ground dolomitic limestone were given at an application rate of 400 lb. per acre.

Green Manure and Shade Trees.—The routine supplying and re-supplying of shade trees commenced in May and continued throughout the south-west monsoon period. Details of plants put out in all fields are as follows :

<i>Grevillea</i> <i>robusta</i> plants 2,537	<i>Albizzia</i> <i>sumatrana</i> plants 3,813	<i>Acacia</i> <i>pruinosa</i> plants 3,182	dadap stumps 2,534
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The large *Albizzia moluccana* and *Albizzia sumatrana* trees in Fields Nos. 5 and 13 were cut out before pruning commenced. All high shade in Fields Nos. 2 and 3 (due for uprooting and rehabilitation in 1961 and 1962) were cut out for firewood. Low shade in the form of dadaps was lopped three times during the year and is well regulated throughout. In Field No. 12 which is the only field due for pruning in 1961, all large *Albizzia sumatrana* trees were ring-barked. These will be cut out early in 1961. The green-manure nursery has been stocked with next year's shade requirements.

Cootch and Illuk.—Several patches of cootch grass and illuk in the mature tea areas received attention during the year and a greater measure of control has been achieved.

New Clearings.—The detailed position of Field No. 1 is as follows :

1953, 1954 and 1957 clonal planting.

Reserved for sale of cuttings and experimental work :

Block No.	Date of Planting	TRI Clone Number	A.	R.	P.
41	October 1953	2024	0	3	6.13
60	June 1954	2025	1	0	29.75
25	June 1957	777	0	2	37.81
			2	2	33.69

A monthly weeding round was completed and spraying against Blister Blight carried out whenever necessary. The T.175 mixture was given on the basis of 1 oz. per plant at four applications for the year with magnesium sulphate 24%. Shade trees were trimmed and overgrown *Albizzia sumatrana* trees were ring-barked. Block 25 was severely attacked by Yellow Mite. Experimental spraying was carried out by the Entomology Division, and the bushes made excellent recovery. 1,170 lb. tea fluff and sweepings was broadcast in Block 25.

1955/56 Clonal Planting

Block No.	Date of Planting	TRI Clone No.	A.	R.	P.
26	June 1955	777	0	2	5.25
28	June 1955	2025	0	1	1.87
30	July 1955	2025	0	0	6.56
43	July 1955	2022	0	2	15.50
44	June 1955	2024	1	0	18.63
46	June 1955	2024	0	3	37.12
48	June 1956	2024	0	0	7.87
49	June 1956	2016	1	1	17.12
55	June 1956	2022	0	2	1.56
56	June 1956	2022	0	2	27.62
59	June 1955	2025	0	0	8.50
			6	0	27.60

All these blocks are in regular plucking, but periodic small-scale experiments are carried out by the T.R.I.

One particular area, a part of block 46, received special attention. This is a weak area which was heavily thatched and planted up with marigolds, after tea fluff and sweepings had been broadcast. Upkeep and maintenance was carried out as described under the previous heading and the application rates of manure and the mixture used were the same throughout.

1959 Clonal Planting

Block No.	Date of Planting	TRI Clone No.	A.	R.	P.
1	June 1959	2026	0	0	33.75
3	June 1959	2025	0	1	28.00
6	June 1959	777	0	0	38.56
14	June 1959	2025	0	2	12.81
15	June 1959	777	0	0	2.62
17	June 1959	777	0	3	30.31
19	June 1959	2023	0	3	9.88
20	June 1959	2025	0	3	00.50
32	June 1959	2025	0	0	33.63
35	June 1959	2026	0	1	26.19
37	June 1959	2023	0	3	3.13
39	June 1959	2025	0	0	3.56
10,12 & 53	June 1959	Kanapediwattie and Illuktenne seed	5	1	22.94
			1	3	34.18
			7	1	17.12

1960 Clonal Planting

Blocks 8A & 8B Planted June 1960—Rehabilitation Period 3 Years

Lining and holing were considerably delayed until it was decided what form the small-scale planting-distance experiments should take. Work commenced in May. Lining and holing were completed towards the end of the month, the entire area was weeded, all Guatemala grass suckers were uprooted and drains were cut. Level terraces were built in steep areas, boundaries and ravines were cleaned, and all cootch patches were attended to. Tea hedges were then planted above all field drains, using smaller plants from the nursery. 6,153 plants of TRI 2025 were used for this purpose. Planting operations commenced in June (14th—18th) and 7,470 plants were put out in the field at a planting distance of 4' × 2'. The clone used was TRI 2025. Experimental blocks (small-scale planting-distance experiments) were planted by the Physiology Division under their supervision.

Shade trees were planted 12' × 12' across the path of the south-west monsoon winds as follows:

dadaps 206 stumps

Albizzia moluccana 104 plants

Grevillea robusta 104 plants

Wind belts of *Acacia pruinosa* had already been established. Forty tons of compost was broadcast between rows and a manurial thatch (empty manure sacks) was laid over the entire area.

Vacancies were resupplied and regular spraying done. All plants received two applications of Sterameal 'A' at 1 oz. per plant, and are growing well.

Factory and Machinery.—Further general improvements in the factory, particularly in the sifting room, were carried out. Individual AC motors were fitted to the Brown's Winnower and the Savage Cutter which was moved to a site adjoining the Tarry Nipper Breaker. All sifting room machinery is now worked on individual AC motors and the old DC motor overhead shafting, pulleys and brackets have been removed.

The furnace brickwork of the Marshall's Empire Drier, which was completely overhauled in April 1959, collapsed in January and again in March and extensive repairs were necessary on both occasions. Complete renovation of this stove has been approved by the Experimental and Estate Committee and Messrs Walker Sons & Co. Ltd. have been asked to undertake this work. A flame-failure protection and an electrically operated valve for the drier pre-heater furnace installation were fitted. No further tests on the Woods Heat Exchanger unit installed by Messrs Brown & Co. Ltd., were carried out during the year.

A new storeroom was built behind the factory adjoining the chest nailing room.

The Rolling, Drier Furnace and Sifting rooms were painted with pleasing colours.

The C.F.I.A. Inspector visited the factory on the 28th March, 26th May and 1st November and carried out fire inspections. Adhering to his report, various alterations and additions were made to the sprinkler system by the Colombo Commercial Co. Ltd.

The head-storage tank (capacity 15,000 gallons) was emptied and cleaned out in March.

An additional block was built behind the rolling room to house new experimental equipment for the Technology Division.

Manufacture.—Three types of manufacture were carried out during the year as follows:

January, February, March & December. .A 4-roll programme, i.e. 4 rolls of 30 min. duration (120 min. rolling). Four periods of roll-breaking of 10 min. duration (40 min. roll-breaking) with $2\frac{1}{2}$ — $3\frac{1}{2}$ hrs. fermentation, charges every 50 min., was carried out during dry periods. Order of firing 2, 1, 3, 4, Big Bulk.

April, May, September, October & November. .A 5-roll programme, i.e. 5 rolls of 30 min. duration (150 min. rolling), 5 periods of roll-breaking of 10 min. duration (50 min. roll-breaking) with $2\frac{1}{2}$ — $3\frac{1}{2}$ hrs. fermentation, charges every 70 min., was carried out during wet periods. Order of firing 3, 2, 1, 4, 5, Big Bulk.

June, July and August. .A 6-roll programme, i.e. 6 rolls of 20 min. duration (120 min. rolling), 6 periods of roll-breaking of 10 min. duration (60 min. roll-breaking) with $2\frac{1}{2}$ — $3\frac{1}{2}$ hrs. fermentation, charges every 50 min. Order of firing 3, 2, 1, 4, 5, 6, Big Bulk.

Brokers reports were satisfactory throughout, particularly on the 6-roll programme. Very little flavour was noticeable during the first three months of the year, but teas were well reported on and a high standard of manufacture was maintained throughout the year.

The percentage of dhools obtained on the various programmes were as follows :

	4-roll	5-roll	6-roll
1st dhool ..	15	12	12
2nd dhool ..	24	22	14
3rd dhool ..	28	23	20
4th dhool ..	30	21	18
5th dhool ..	—	17	19
6th dhool ..	—	—	12
Big Bulk ..	2	4	4
	99 %	99 %	99 %

Grade Percentages

	1960	1959	1958
Broken Orange Pekoe	72.80	72.95	72.86
B. O. P. Fannings	8.07	8.28	8.31
F. Pekoe ..	2.98	3.01	2.72
Fannings ..	4.82	—	—
Fannings No. 2 ..	—	3.82	3.63
Broken Pekoe ..	.66	—	—
Broken Mixed No. 1	—	6.69	5.92
Broken Mixed ..	6.11	—	—
Orange Pekoe ..	—	.42	1.58
Dust ..	4.44	—	—
Dust No. 1 ..	—	4.43	4.50
Experimental Teas	.12	.40	.48
	100.00 %	100.00 %	100.00 %

	1960	1959	1958
Out-turn of made tea to green leaf ..	23.91 %	21.65 %	22.23 %

The experimental manufacture and testing of Instant Tea commenced in March.

Labour.—Children and brides were registered during the year and 25 labourers were retired. Health was generally good. The labour force co-operated with the management throughout the year, but there was some unrest due to a split among members of the same union. However, this did not affect the smooth working of the estate. There are now two factions of the Ceylon Workers' Congress on the estate. After a stormy meeting to which all labourers were summoned at the request of the Union officials and in their presence to ascertain the strength of the rival factions, it was decided that until a satisfactory settlement could be reached over the election of Office Bearers, there would be no appointed Committee for a period of six months. In the meantime one spokesman from each faction was appointed to deal orally with the management.

Owing to the large number of casual labourers employed on St. Coombs by Messrs Brown & Co. Ltd., on new buildings and the new filtration plant and water supply, it became exceedingly difficult to maintain discipline among estate labourers. Petty theft increased considerably during the year.

The annual sami-kumbudu was held during the week-ending 20th March and lasted three days.

	Men	Women	Children	Total
Working labourers on estate as at				
31st December, 1959 ..	245	238	18	501
Non-working labourers (Pensioners)	31	20	—	51
Total estate population ..	293	259	506	1058

Working labourers numbered 1.72 per cultivated acre and the percentage of out-turn was 84%. One fifth of all labour was used by the Institute for experimental work. In accordance with the Visiting Agent's recommendation contained in his report dated 27th April, 1960, the total working labour force will be restricted to 500.

Looking to the future, it is apparent that a serious problem will present itself within the next five years in view of the extremely high natural increase.

Buildings and Lines.—The total number of units all up to Government standard is 36 sets—213 rooms. The number of workers per room is 2.35 and the number of souls per room is 4.97. During the year under review several roofs were painted with black bituminous paint, a large retaining wall was built in the colony close to the main cart road below the factory, annual whitewashing was carried out and all necessary minor repairs completed. A large bank behind Line No. 2 (82 cubes of earth) was cut and removed. A new double storey line completed in 1959 was occupied this year. Two sets of lines, P.A. Health Scheme Plan No. E/LQ/7(A) cottage type, were completed. Line No. 27—4 rooms, situated behind the present caddy, was demolished.

Another cattle shed to accommodate six head of cattle was built. There are at present 64 head of cattle and 101 goats on the estate. The fly nuisance, a regular feature every year, was fully controlled by better sanitary methods and regular spraying which was carried out under the personal supervision of Mr J. E. Cranham, Entomologist, and his staff to whom a hearty vote of thanks is due for the manner in which this serious nuisance was kept under control.

An extension to the estate office was completed, guttering and down-pipes were fitted to the estate office and rice store, the roofs of the estate office, rice store, Head Teamaker's, Sr. Asst. Clerk's, Jr. Asst. Clerk's, Tractor Driver's Quarters, the engine room and firewood shed were painted. Quarters for a single member of the staff was also completed.

Replanting—1961 Replanting 10 Acres—Regular upkeep, namely weeding, manuring and lopping Guatemala grass, removal of cootch, and thatching, was carried out in the 1961 replanting area—10 acres in two 5-acre blocks adjoining Field No. 14B and Llan Thomas division. It is intended to carry out planting-density and fertiliser-distribution trials in these areas.

1962 Replanting—15 Acres—Uprooting commenced in May and 6½ acres in Field No. 7 and 8½ acres in Field No. 8 were uprooted by hand on contract, the work being completed, entirely satisfactorily under close supervision. Deep forking to a depth of 18" was done, the ground levelled and all old drains covered over. Guatemala grass was planted, all leader drains were stone-bunded and terraced and boundaries cleaned. The first application of Guatemala-grass manure mixture was broadcast at 4 cwt per acre and the grass lightly lopped. Regular weeding was carried out.

1963 Replanting—14½ Acres—Slaughter plucking of these areas commenced towards the middle of the year as soon as the programme for uprooting was accepted. These areas which are to be uprooted in 1961 comprise 6½ acres in Field No. 7 and 8½ acres in Field No. 2. All high shade was removed and only essential field works are carried out. Regular manuring is done.

Playground—Work on the new playground commenced in February. The gum stumps were uprooted and levelling by tractor was done. Owing to several set-backs, namely adverse weather throughout the year and an encounter with slab rock in the middle, work was considerably delayed. It is hoped to complete the ground fully in 1961.

Visiting Agent—Mr. Alexander Mackie visited the estate on three occasions during the year on the 25th April, 18th August and 19th December.

General—The year under review has been an extremely satisfactory one. Crop intake was the highest ever recorded and naturally the yield per acre was an all-time record. The cost of production was also low compared with previous years. Favourable weather conditions no doubt had a lot to do with the ultimate result. However, there was no flavour season and the final nett-sale average suffered as a result of this. The general appearance of the tea is good and altogether a very sound agricultural policy was followed throughout the year. The factory is well equipped with the exception of the rolling room where at least three rollers need replacing within the next three years. All new plantings show promise of developing into excellent fields of tea. The estate worked in very close co-operation with the Institute and all aspects of research in the field were given top priority. Advice and assistance on any problem affecting the estate was freely given by Officers of the Institute.

We now look forward to a good season in 1961.

METEOROLOGICAL OBSERVATIONS - 1960
ST. COOMBS
(Laboratory Gauges)

MONTH	TEMPERATURE OF							RAINFALL		RAINY DAYS		SUNSHINE	
	Mean Maximum	Difference from Aveg. (25 yrs.)	Mean Minimum	Difference from Aveg. (25 yrs.)	Adopted Mean	Mean on Grass	Mean Relative Humidity	Inches	Difference from Aveg. (25 yrs.)	Days	Difference from Aveg. (25 yrs.)	Hours	Difference from Aveg. (25 yrs.)
January	72.8	- 1.3	56.7	+ 1.0	64.8	51.7	74	4.33	+ 0.73	14	+ 3	173.38	- 19.32
February	71.0	- 5.3	57.1	+ 2.5	64.1	52.4	80	8.63	+ 6.28	16	+ 8	149.15	- 61.53
March	75.5	- 2.2	54.3	- 1.2	64.9	54.8	70	3.51	- 1.03	9	- 3	244.55	+ 11.54
April	75.4	- 2.0	57.6	- 0.2	66.5	57.5	77	8.97	+ 2.60	19	+ 3	198.22	+ 1.78
May	71.7	- 0.7	60.9	+ 1.2	66.3	61.4	85	9.33	- 1.95	29	+ 11	104.40	- 59.60
June	69.8	- 0.8	60.5	+ 0.1	65.2	59.6	84	8.52	- 4.58	27	+ 1	103.95	+ 11.91
July	69.7	- 0.5	59.9	+ 0.4	64.8	58.3	88	10.22	- 1.52	29	+ 3	68.70	- 36.49
August	72.3	+ 1.3	59.6	+ 0.4	66.0	57.7	85	8.15	- 1.27	22	- 3	117.20	+ 3.04
September	67.6	- 4.6	60.0	+ 1.8	63.8	58.7	92	19.35	+ 10.98	26	+ 5	44.06	- 96.26
October	72.8	- 0.3	56.8	- 0.9	64.8	51.5	83	8.88	- 0.81	19	- 3	176.98	+ 27.62
November	71.3	- 2.2	57.5	+ 0.4	64.4	53.9	84	11.05	+ 3.63	25	+ 6	96.15	- 65.37
December	74.1	+ 0.6	56.9	+ 0.8	65.5	53.3	77	1.05	- 4.17	8	- 7	209.65	+ 40.42
	72.0	- 1.5	58.2	+ 0.5	65.1	55.9	81.6	101.99	+ 8.89	243	+ 24	1686.39	- 242.26
	Means							Totals					

REPORT OF THE CHIEF ADVISORY OFFICER FOR 1960

C. B. Foster-Barham, M.A.

Correspondence.—During 1960, 1676 letters were received and 1505 sent out, the number of separate enquirers being 614. Out of the 1100-odd amalgamated groups and single company and privately-owned tea holdings in Ceylon, as registered in the 1960 Ferguson's Directory, 445 or about 40 per cent made use of the division. There were in addition 169 persons, including directors and representatives of tea companies, commercial interests, research institutes, agency houses and their visiting agents, Government Agents, and private individuals, both in Ceylon and abroad, who corresponded.

Enquiries were received from all except 2 of the 50 tea-growing districts. These two were small districts involving only some 6 tea holdings and about 1400 acres.

Visits were made to 60 estates in 22 different districts.

Other divisions of the Institute dealt with special enquiries and paid visits that are not included in this summary.

Specimens and Soil Samples.—Amongst the considerable numbers of specimens submitted for examination, diagnosis, and report, there were 191 cases of fungal disease, 238 cases of pest attack excluding eelworm, and 142 cases attributed to faulty soil conditions, to adverse weather, and to faulty husbandry. Amongst leaf samples, there were 45 cases of deficiency and 3 of excessive uptake of nutrient.

In regard to soil samples, 1223 were examined for pH. Eelworm samples involved some 1098 separate examinations for parasitic species and, of these, 997 revealed freedom from or slight degree of infestation, while 101 revealed moderate or heavy infestation. Owing to the amount of time-consuming work involved in carrying out eelworm examinations, the Nematology Division discontinued routine examinations as from the 15th of November, and it now handles only soil samples required for research purposes. Estates and persons who require examination of soil for eelworm now send their samples to Colombo to Messrs Baur & Co., to Messrs Harrisons & Crosfield Ltd., or to Messrs Colombo Commercial Co. Work on pH analysis is not affected and estates may continue to send soil samples for pH purposes only.

Appreciation of Enquiries Received During 1960.—A summary has been made of enquiries received by the Advisory Division. While it cannot claim to be a quantitatively representative sample of the troubles affecting tea in Ceylon, some information of interest does emerge from it. Only the more important matters are mentioned below.

Manuring.—As a single subject, manuring occupied first place, 162 enquiries from estates and 42 from other sources having been received. Connected with these were also 45 cases of deficiency and 3 of excessive uptake of nutrients in leaf examined.

The most frequent enquiry concerned magnesium with 69 enquiries of which 61 referred to dolomite and magnesium sulphate. Apart from those,

168 enquiries referred to general manuring policy and specific policy concerning nitrogen, phosphate and potash. Enquiries for general information on the manuring of tea numbered 14 ; those concerning the manuring of young tea and also requests for examination of soil samples for possible nutrient deficiency both numbered 9. The last figure is possibly surprisingly low but the explanation is that analysis of soil by any method known at present gives only very limited information regarding manuring required. The Institute prefers examinations of leaf rather than soil analyses for determining nutrient deficiencies. Foliar analysis, however, requires further research before correlations can be placed on a statistically proven footing.

Enquiries on manuring were in general fairly well distributed over the tea districts, and were received from 70 % of the total number.

Vegetative Propagation.—103 enquiries, other than requests for examination of soil samples and specimens, were answered on this subject, and covered 48 % of all districts. This figure would appear to be low, but may probably be accounted for by considerably more enquiries being sent direct to the V.P. Officer.

Of enquiries of a general nature, requests for information on selection and vegetative propagation numbered 15, and requests concerning particulars of different clones and their sources of supply the same number.

The chief difficulties which estates encounter in their V.P. work appear to arise from faulty soil in their nursery beds, cuttings failing to root successfully. Samples of soil examined for texture fairly often have too high a percentage of clay, which is apt to impede drainage ; organic matter assists in lightening the texture and helping to preserve air space and also micro-channels for proper drainage. Plant specimens sent together with soil of excessively clayey texture are very often over-callused at the base of the stem, with a total absence of rooting, or callus formation may be found part way up the stem while the portion below the callus has rotted. In a few cases Mealy Bugs are found amongst the callus. Heavy rain appears to have been responsible for a number of failures ; but its effects could be lessened by the careful selection or compounding of nursery soils for proper texture. Heavy or persistent rain requires careful attention to shade and avoidance of erosion by dripping.

In V.P. clearings, fairly frequently, problems were encountered in connection with micro-climate and underlying soil conditions, the latter being mainly associated with pests and with root and stem diseases. There occurred, for example, cases where thatch had been placed, or had been allowed to become displaced down slopes, so that it came too close to the collar, causing scorching during hot sunny weather or rotting during rainy weather. Under hot dry conditions there were also found occasional cases, in Uva and in Dimbula, of restriction of air circulation in thatched clearings. Troubles were associated mainly with the practice of allowing inter-row hedge plantings of leguminous crops to grow too thick and tall, and omitting to thin out or lop to a suitable height in time.

V.P. Cuttings Under Glass.—An enquiry of possible interest to planters whose V.P. cuttings suffer under heavy rain conditions came from an estate at over 6000 ft. elevation, and involved the raising of cuttings under glass. Some success appears to be possible if the under surface of the glass is coated with a lime wash, as in green houses growing market-garden crops, the coated surface acting as a protection against excessive sunlight and also helping to preserve moisture. Figures of costs are unfortunately not yet available, but are likely to be high.

Substitution of Polythene Bags for Baskets.—During the year polythene began to come into use as being cheaper and more durable than baskets, besides helping to conserve moisture in the soil to a greater degree during dry weather than the open weave of a basket ; up to the end of the year 7 enquiries had been received. The durability of the polythene bags used at St. Coombs for this purpose has extended to well over a year, and root development, owing to the extra conservation of soil moisture, is often extremely good. Drainage, while in the nursery blocks, is provided by punching two or three rows of holes with a letter punch along the base of the bag. When ready for the field, the bag may be slit with a knife, the polythene slipped off, and the plant inserted into its hole with a minimum of root disturbance. Disturbance during transport to the site of plantings is also probably less as cylindrical bags pack better than conical baskets.

Pests and Diseases—General Comments.—The most common occurrences were of Shot-hole Borer, mites, eelworm and *Poria*. Amongst specimens examined in the laboratory during 1960, there were 59 cases of mite attack, 59 of Shot-hole Borer and 54 of *Poria*. Shot-hole Borer specimens were received from 27 districts, and other enquiries on this pest were received from 17. Districts recording the most numerous cases were Badulla, Maskeliya and Pussellawa, with slightly less in Dimbula and Udupussellawa. Mite attack was most frequently recorded from Badulla, Dimbula, Dickoya and Madulsima. Of the different species, there were 21 occurrences of Yellow Mite, 16 of Scarlet Mite, 11 of Red Spider and 11 of Purple Mite submitted for examination. Amongst districts with *Poria*, the highest figure by a long way came from Dimbula, with Pundaluoya and Ramboda equal second. The next most common occurrence were 43 new cases of Charcoal Rot Disease (*Ustilina*) of which 9, 7 and 6 are recorded for Dimbula, Madulsima and Badulla districts respectively. Brown Root Disease (*Fomes noxius*) recorded 25 cases, of which 11 were in Badulla district, and of Black Root Disease (*Rosellinia arcuata*) there were 21 cases, of which 6, the highest figure, were recorded from Dimbula district.

Soil sample examinations for parasitic eelworm showed that the heaviest infestation occurs in Dimbula and Maskeliya districts, with Dickoya, Nuwara Eliya, Ramboda and Haputale as subsidiaries. Both the Meadow and Root-Knot species were heaviest in Dimbula and Maskeliya. Of the 1098 soil samples for both parasitic species received by the Advisory Division during 1960, about 5% had heavy infestations, and another 5% moderate infestations. These figures are not representative of eelworm infestations over the Island, for out of the 50 listed tea districts, 23 did not request any examination.

Blister Blight.—25 enquiries were recorded, and this is a low figure involving 11 districts only. Familiarity with now well-established methods of control probably accounts for this. On the latest methods, and potentially new methods of achieving economy, there were 13 enquiries about sunshine recording, and 12 on motorized power sprayers and dusters.

Tortrix.—17 new outbreaks were recorded from 9 districts of which the most numerous occurred in Dickoya (7) and Dimbula (3).

Other Causes.—There were 23 cases in 14 districts of die-back and wood rot, 17 cases of collar rot and scorch, and 10 of damage by lightning.

Declining and Static Yields.—A few estates, 7 in number, requested investigation on this subject in 6 separate districts. In the majority of cases these were found to be associated with factors of age, reduction in the nitrogen ratio, magnesium and potash deficiencies, Shot-hole Borer with concomitant starch deficiency, drought, and mites.

Submission of Specimens for Diagnosis and Report.—It is still fairly common for specimens to arrive too dry for accurate determination of cause of death or debilitation, or too long after the incidence of the original cause ; or sufficient information regarding the circumstances of the case is lacking. Sometimes only parts of plant specimens are sent, and a request to send whole specimens with soil will then reveal causes not previously apparent. In cases of doubt, where the causal organism itself is not plainly visible, I would strongly urge that whole bushes with soil be sent. Perishable material such as leaves and insects also tend to deteriorate in the post. Non-bulky samples of this nature should always be packed in polythene bags secured by sealing or folding over and stapling the open ends. Since it is not possible to follow up every enquiry involving plant specimens by a visit, Superintendents of Estates are at the same time urged to submit specimens which are as representative as possible of the condition or conditions observed by them; otherwise true causes or complete pictures of situations may sometimes escape notice, and further requests for specimens may become necessary.

Staff Matters.—The Chief Advisory Officer attended the U.P.A.S.I. Annual Conference held at Coonoor in the Nilgiris, Southern India, on the 25th of March, and later visited estates in the neighbourhood. Grateful thanks and deep appreciation are here recorded to both the organizers of this conference for their invitation, and to the Superintendents of Estates for their kind hospitality.

Mr L. M. de W. Tillekeratne proceeded from the Institute to the United States in the latter half of August, and is now undergoing a course of studies in Agricultural Education at Davis, California, with reference to extension work on his return.

Mr J. V. Sabanayagam is at Ontario Agricultural College in Canada, where he is studying for a B.S.A. degree in Plant Pathology.

Mr D. J. M. Hettiarachi was appointed as Photographer and joined the Advisory Division on the 1st of January.

It is expected that Mr D. T. Wettasinghe, recently appointed as Research Assistant in the Advisory Division, will be taking up duties on the 1st of March, 1961, from the Technical Training Institute, Amparai.

Visitors.—Besides numerous personal visits from superintendents of estates, there were also numbers of parties consisting of final year students in Agriculture, students from schools, Technical Training Colleges and commercial organizations, and others interested, who were conducted around the Institute's laboratories, experiments and the factory. Individuals in parties numbered altogether about 160.

Exhibitions and Shows.—The Advisory Division, in co-operation with the other Divisions of the Institute, organized exhibits on various aspects of tea cultivation at the Agri-Horticultural Show held in Nuwara Eliya from the 28th to 30th April, and at the Ceylon Economic Development "New Age" Exhibition held in Colombo from the 1st to 10th September, the latter being organized in co-operation with the Ceylon Tea Propaganda Board and the Tea Control Department.

ANNUAL REPORT OF THE LOW-COUNTRY ADVISER FOR 1960

A. W. R. Joachim, O.B.E., Ph.D., F.R.I.C., Dip. Agric.

General.—My main activities during the year related to : (1) the search for a suitable low-country sub-station; (2) the supervision and statistical analysis of the data of experimental work on estates; (3) advisory and extension activities; and (4) the organisation, development, and control of the vegetative-propagation sub-unit at Kottawa in the Galle district.

Considerable attention was given to the question of the selection of an estate for the low-country sub-station. For reasons connected with the high over-all cost of the scheme which would have resulted from its choice, the proposal to purchase an estate in the Ratnapura District instead of Mutwagalla estate had to be abandoned. Inquiries were thereafter made from Agency Houses as to whether a suitable division of an estate under their charge could be made available and an offer was received. A committee of technical officers consisting of the Chemist, Plant Physiologist, Chief Advisory Officer and the Low-country Adviser reported on the relative suitability, from the experimental standpoint, of three properties which had been proposed for the sub-station. Of these, the Committee decided that the offer referred to above of a division of an estate in the Ratnapura District was the most suitable. Negotiations for its purchase were in hand at the end of 1960.

The Division operated with the following cadre during the year : the Low-country Adviser, the technical assistant to the adviser, and the Officers-in-Charge of the Endane and Kottawa sub-units. Except for Mr A. E. T. Ellawella, who resigned his post as technical assistant at the end of June and was replaced by Mr U. L. M. de Silva, the personnel remained much the same. Mr H. G. K. Gunapala was appointed technical assistant from October 15th and assumed duties at the Kottawa unit for training.

An important event during the year was the visit by Dr F. R. Tubbs, C.B.E., (Adviser in the U.K. to the Board of the Institute) to the low country from the 21st to the 26th of July. A programme of meetings of Planters' Associations in the low country and of visits to estates was arranged in order to give Dr Tubbs an opportunity of studying the developments that have taken place in the zone since he was last in the Island. Professor G. E. Blackman, F.R.S., a member of the Scientific Advisory Committee in the U.K. also visited the low country on the 16th and 17th of September.

I acted for the Director from the 17th October to 27th November when he was on leave in the U.K.

Advisory and Extension Activities.—Correspondence continued to be heavy, the number of letters sent during the year being 1,420. These were mainly of an administrative nature. Altogether 36 meetings were attended of which 21 were meetings of the Planters' Association, Low-Country Planters' Association and District Planters' Associations. Addresses were given at a number of them and these related mainly to development connected with the low-country sub-station. Technical addresses were, however, more numerous than in previous years. Four meetings of the Low-country Committee were held.

The number of visits made to estates during the year totalled 104. Of these 51 were to Palmgarden and Endane estates where manurial and other trials are being conducted and to the V.P. Unit at Kottawa. The remaining 53 were to estates in the area for observational or advisory purposes. Included in this number were two visits to the Pelawatte Government Tea Plantation, of which a soil survey had previously been made by me.

Three soil reconnaissances were carried out, at the instance of the Government, of lands proposed for developments under tea cultivation in the Kalutara, Galle, and Matara districts respectively. Of these the Kelinkanda Scheme in the Kalutara District was the most important. It comprised an extent of about 2,000 acres of land of variable topography and character. The general finding was that the soil and climate conditions were suitable for the cultivation of tea, but that special measures would have to be taken if the land was to be developed as a peasant colonisation scheme.

KOTTAWA V. P. STATION

The difficulties connected with alienation by Government of the 25-acre block of land at Kottawa in the Galle District for the purpose of establishing a Vegetative Propagation unit for the area were resolved during the year. Thanks to the valuable assistance rendered in this connection by Mr H. B. Goonewardene, J.P., the few squatters were peacefully removed from the land.

Work on the station was started in May and 10 acres of the land have been cleared and planted with Guatemala grass. This area has also been soil conserved and roaded. Two rows of the species *Fragra fragrans*, recommended and supplied by the Forest Department, have been planted out as wind-belts.

Plots and nurseries for the Plant Physiologist's clonal varietal trial have been prepared and laid down. 58,000 cuttings have been propagated and root samplings of these have been carried out regularly. So far, 31 assessments have been completed.

A small block of land isolated from the main area has been set apart for the experiment by the Nematologist on the development of the meadow eelworm under low-country soil conditions.

The roads and bridges leading to the unit have been completed. Plans for the necessary buildings have been approved and a start will shortly be made on them.

RESEARCH

The experimental programme undertaken by the division during the year comprised the following items of work: (i) manurial experiments at Endane and Palmgarden estates; (ii) cultural experiments at Endane; and (iii) manufacturing tests with clones. Other lines of investigation carried out were: (iv) responses to manuring on low-country estates; and, (v) statistical procedures in experiments with tea.

(i) a. **Manurial Experiments at Endane.**—This experiment completed its third cycle in April. The data were subjected to a detailed statistical examination as a general analysis showed *no* significant differences between treatments. This was most disappointing, as the same result was obtained from the data of both the first and the second cycles, indicating that even after nearly 5 years of experiment, there are no significant yield differences whether 80, 120 or 160 lbs. of nitrogen per acre per annum or 60, 90 or 120 lbs. of potash or 0, 30 or 60 lbs. of magnesium oxide are applied to the plots singly or in combination. Nor are there any strong trends shown except in regard to the nitrogen-magnesium

interaction, which appears to indicate that magnesium may become a limiting factor of yield when nitrogen is applied at the higher levels. The table below gives the average yields per plot during the cycle of 1½ years, approximately:

Table 1. Average Yield of Green Leaf Per Plot of 1/20th Acre

Nitrogen	80 lb./acre	120 lb./acre	160 lb./acre
Yields	500.0	504.2	498.9
Potash	60 lb./acre	90 lb./acre	120 lb./acre
Yields	505.0	499.8	497.9
Magnesium Oxide	none	30 lb./acre	60 lb./acre
Yields	493.7	505.8	503.6
Calcium	single	double	
Yields	500.0	500.2	

Significant difference ($P=0.05$) = 18.1 lb.

„ „ ($P=0.01$) = 23.8 lb.

In order to ascertain the reasons for this unexpected result, bush counts were made in the plots and the average stand worked out at only about 3,250 bushes per acre. The individual bush counts were then subjected at an analysis of co-variance with yields and when the first cycle yields, which were recorded as dry weights of tea, were correlated with plot bush number made early in 1959, the significantly-high correlation ratio of 0.7155 was obtained. Yields and bush numbers were significantly linear, the regression equation working out at $y = 0.66x + 13$, where y = yield and x = the bush number. When, however, the yields of the plots in the second and third cycles, which were recorded as weights of green leaf, were correlated with the bush counts made in 1959 and 1960, the correlation coefficients fell to about 0.51 in both cases. Whether this lower, but significant, ratio was due partly to the effects of the treatments in individual plots (though not significant as a whole), or partly to the recording of the data as green leaf or to other factors, cannot be determined. But it is clear that yield is affected, partly at any rate, by bush number.

A point of importance that has emerged from the statistical studies on the analysis of co-variance between yields and bush numbers, is that the “relative efficiency” of the experiment increased according to the cycle from 172% to 300% by the adoption of this technique. Standard errors per plot were reduced from 9.7% to 7.3% in the first cycle and from 9.7% to 5.5% in the third cycle. The routine recording of bush numbers in all experiments, as well as the crop, is well worth while and is to be recommended.

On the plots at Endane the numbers of green manure trees—*Gliricidia*, dadap and *Albizia*—vary appreciably and it is not unlikely that this factor, both in respect of the varying shade and amounts of loppings, must affect yields. With the new cycle, records will be kept of the amounts of green loppings per plot at each cut. The total amounts of nitrogen and other elements returned to the soil in an easily-available form can thus be estimated. At a conservative estimate, this will work out to about 80 lb. of nitrogen per acre per annum.

In view of the results noted and the likelihood of no further information being obtained if the experiment were continued as originally planned, with the approval of the estate authorities in the U.K. and the support of

Mr A. Watt, the Manager, modifications were introduced in respect of the treatments, as follows : (a) the levels of nitrogen were reduced to 0, 40 and 80 lb., of potash to 40, 60 and 80 lb., and of magnesium oxide to 0, 20, and 40 lb. per acre per annum respectively; (b) calcium was omitted as a treatment in order not to complicate the elucidation of the potash problem consequent on the generally high manganese content of the tea.

For unavoidable reasons, however, the first application of calcium as gypsum was given to the three blocks. The application, unlike in the previous cycle, had no effect whatsoever on tipping leaf as the following will indicate:

			Tipping leaf lb. per acre
With Calcium	..	..	1,430
Without Calcium	..	..	1,414

Plucking started on 12th August 1960 and the yields of treatments as green leaf to the end of December 1960 after 21 pluckings were :

Treatments				Yield lb. per acre green leaf
N ₀	..	..	..	2,973
N ₁	..	..	..	3,050
N ₂	..	..	..	3,000
K ₀	..	..	..	3,025
K ₁	..	..	..	2,998
K ₂	..	..	..	2,999
Mg ₀	..	..	..	2,980
Mg ₁	..	..	..	3,053
Mg ₂	..	..	..	2,990

The maximum difference between treatments does not exceed 2.7 per cent and treatment differences are, therefore, not significant so far.

Some important changes were also introduced in the conduct of the experiment. These are as follows: (i) the dry-weight estimations of leaf samples from plots are determined every alternate plucking for comparison with the fresh weights; (ii) weights of green-manure loppings per plot are being maintained over the cycle; (iii) counts of bush numbers per plot are recorded at the beginning of the cycle for analyses of co-variance between yield and bush number; (iv) the method of application of manure was altered, applications subsequent to the first being broadcast.

(i) b. **Manurial Experiment on V.P. Tea at Palmgarden Estate.** With the kind co-operation of Mr H. D. Ross, Manager of Palmgarden, a trial has been started to ascertain the effects of 4 factors at 3 levels, viz: nitrogen at 150, 300 and 450 lb. per cycle of 2 years; potash at 75, 150 and 225 lb. per cycle; magnesium at 0, 48 and 96 lb. of magnesium oxide per cycle; and three frequencies of application—3, 6 and 9 applications per cycle. In all 81 treatments will be compared. The design is a 3⁴ confounded block design of 9 plots each in one replication and has been recommended by Dr S. C. Pearce of the East Malling Research Station, U.K. The clone on which the trial is being carried out is TRI 2023. For a period of about a year, pre-treatment records will be carried out for purposes of calibration.

Yields so far from 40 pluckings taken at 5-day intervals average 4.5 lb. of green leaf per plot of 1/57th acre, the average yield of individual plots ranging from 3 to 6 lb. The highest yields are generally obtained in the lowest contours and the lowest yields in the highest contours. Two points emerge from

these initial yield records: (i) the importance of the location of plots in experiments with V.P. tea; (ii) the value of pre-treatment recording in experiments with such tea. Data on seedling tea also confirm the latter finding. The 4-year old field of 5 acres on which this trial is being conducted is giving an average yield of 3,400 lb. per acre per annum at present.

(ii) Cultural Experiments at Endane

(a) BRINGING-INTO-BEARING TRIAL. This trial which was initiated by the Plant Physiologist was concluded at the end of June. Dr Visser will deal fully with the results obtained, but in general it may be stated that under the experimental conditions, bending and controlled thumb-nailing and thumb-nailing alone give 16-23% more yield than centering. Bending followed by cut-across treatments as followed at Endane and Ederapolla gave 7% more yield than centering over 22 plucks.

(b) PRUNING-CUM-PLUCKING EXPERIMENT. This experiment, which was also initiated by Dr Visser, was concluded at the end of November 1960, as it was considered that under the experimental conditions it could not provide more information than had already been obtained in respect of the duration of the pruning cycle. The data relating to systems of plucking (single-leaf *versus* single-plus-fish-leaf) has already been published by the Plant Physiologist (Visser, 1960). The pruning cycle data show that there is little difference in yield between the 18-month and 2-year cycle after 4 years of trial. The 3-year cycle has, however, given a markedly lower yield, though the manurial application was not appreciably different. This is attributed to the difficulty of plucking these plots adequately during the last year of the cycle. The average yields during the 4-year period were as follows, *S* representing single-leaf plucking, and *S/F* single-plus-fish-leaf plucking.

Cycle years	Nitrogen (High Manuring) lb. per acre/annum	Yield (lb. per acre/annum)		
		<i>S</i>	<i>S/F</i>	Average
1½	179	1,609	1,741	1,675
2	169	1,557	1,798	1,677
3	165	1,339	1,546	1,442

Cycle years	Nitrogen (Normal Manuring) lb. per acre/annum	Yield (lb. per acre/annum)		
		<i>S</i>	<i>S/F</i>	Average
1½	115	1,482	1,717	1,600
2	114	1,494	1,711	1,602
3	115	1,320	1,466	1,393

General Average

Cycle years	Yield lb. per acre/annum
1½	1,637
2	1,639
3	1,418

The result in regard to the 3-year cycle is in contrast to what was obtained in the pruning-cycle trial at Ingiriya where this cycle showed only a slightly lower average yield than the 18-month cycle. The probable reason for the different result in the present trial has already been indicated.

(iii) Manufacturing Tests with Clones.—With the co-operation of the Institute and through the good services of the Technologist, an experimental

roller able to take 30 lbs. of withered leaf was made available and installed at Pelmadulla Group. Systematic tests were carried out by the Manager on clonal and "seed" leaf. Some of the clones are the standard TRI clones and others are local clones. The samples were reported on by the firm of Messrs John, Keell, Thompson, White Ltd. The reports on the samples of the first series of trials are somewhat conflicting but according to the tasters, Pelmadulla "seedling" tea has so far given much the better result, with TRI 25 the best of the clonal samples. Many of the liquors were reported to be unpleasant (harsh and bitter) in character. A second series of trials has just been started.

(iv) **Responses to manuring on low-country estates.**—A statistical examination was made of the yields of a representative number of estates in the low country over a period of 12 years, to determine the responses to manuring. Very divergent results were noted, average responses varying from approximately 0.8 to 9 lb. of crop per lb. of nitrogen applied as T.500 or T.521. In few instances where the analysis of the data was valid, potash did not appear to be of advantage when applied in other than standard amounts.

(v) **Statistical procedures in experiments with tea.**—(a) Reference has already been made to the relation between bush numbers and yield as gauged from the Endane manurial trial data. The calculation of the precision or predictability index ($1 - \sqrt{1 - r^2}$) where r = the correlation ratio, showed that of the factors involved, bush number contributed about one-third of the crop yield under these conditions.

(b) **Yield records of fresh versus dry weight of tea leaf.**—Following the statistical co-variance procedure adopted by Eden, suitable data from the manurial and pruning-cycle experiments at Endane were utilized to determine the validity of using fresh-weight yields of plots instead of the time and labour-consuming dry-weight yields in field experiments with tea. The analyses clearly demonstrate (and confirm Visser's earlier observations) that, under the conditions of these trials at any rate, the adoption of this procedure is perfectly valid for estimating the significance of the treatments in relation to the experimental errors.

Manurial Experiment

	Degrees of freedom	Correlation coeff. (r) calc.	r(significant)
Treatments	8	.9647	.7977 (P = .01)
Error	40	.9717	.3982 (P = .01)
	53	.963	.3540 (P = .01)

Pruning Experiment

	Degrees of freedom	Correlation coeff. (r) calc.	r(significant)
Treatments	3	.998	.999 (P = .01)
Error	63	.997	.32 (P = .01)
	71	.988	.30 (P = .01)

Pests and Disease Control Research.—The full co-operation of the division was extended to the Plant Pathologist in his investigation of the causes and amelioration of maintenance-leaf fall, which is a common feature of tea in the low country and which is reported to reduce yields or keep them in check. A complex of pathological and physiological factors is considered to be responsible for the trouble. A trial has been started by Dr Mulder at Millakande Estate, Bulathsinhala.

Shot-hole Borer continues to be the main pest problem in the zone. This is receiving the whole attention of the Special Entomologist, Dr E. Judenko,

and the part-time attention of the Entomologist at St. Coombs in respect of extension trials on estates with dieldrin. A few low-country estates are co-operating in the scheme.

Observational.—The following observations which emerge as a result of visits to estates in the low country during the year will be of interest to planters in the zone.

(i) The use of old manure bags to cover the space between rows of young tea has proved both economical and beneficial. The benefit is partly due to the release of the absorbed fertilizers but can mainly be attributed to the mulch effect of the material in controlling weeds, conserving soil and moisture, and protecting the soil from undue exposure to the sun.

(ii) Magnesium deficiency is much more prevalent in the low country than is generally realised, both in old seedling and in clonal tea. The adoption of the Institute's recommendations in regard to the application of dolomite for old tea and of soluble magnesium salts for young tea (and V.P. tea in particular), should result in improvement of crop condition and yield.

(iii) In the low country, centering of young V.P. plants at a fixed height may result in appreciable losses of plants unless an adequate number of lungs or maintenance leaves is left. The plants develop a "little-leaf" condition and bunching, and their starch contents are very markedly deficient.

(iv) The "half pre-prune" to which reference was made in last year's report and which has been tried out on Hemingsford estate, is reported to have given very satisfactory results. The annual yield of a field, for the first cycle, after such pruning, rose from 876 to 1,024 lb/acre, an increase of about 15 per cent. Though this increase cannot entirely be assigned to the new pruning method, the present condition of the bushes would lead one to infer that it has materially contributed to the result.

(v) First generation bi-clonal seed of TRI 2023 x TRI 2026 obtained in 1958 from an isolated seed garden of an acre extent on Hapurugalla Estate, Ratnapura District, is showing promise on Rambukkanda Estate where a $\frac{1}{4}$ -acre extent of such seed has been planted out. The bearers are now 4 years old. $1\frac{1}{2}$ maunds of seed were obtained in 1960 and these have been planted out at Millewitiya Estate.

(vi) Three sprayings with copper fungicide at the usual rates for blister-blight control, cleaning of the bushes, and removal of old shade trees is reported to have effectively controlled Red Rust on tea on a field badly attacked with the disease. No copper spraying had previously been done on the estate. Yields have since been reported to have shown a good rise from quite a low initial level.

(vii) More evidence has been forthcoming of the benefit of a small amount of saphos phosphate in promoting the rapid growth of leguminous shade trees like *Gliricidia*.

Conclusion

Yields on many low-country tea estates are continuing to rise and the Tea Controller's report for 1959 shows that production in the zone, as a whole, is on the increase. But the survey of yield responses to manuring indicate that limiting factors are operative on some estates, and these have to be investigated and corrected for, if full benefits are to be derived from the heavy applications of fertilizers now being given on them. Whether shade is the major limiting factor of response to manuring on these estates, the co-operative

trials it is proposed to start shortly should reveal in due course. Meantime, there can be no slackening of effort in all phases of tea cultivation and manufacture in the low country, if we are to meet the increasingly severe competition which our teas are experiencing in their traditional markets.

In conclusion, I must express my sincere thanks to the Managers of the estates who have so readily afforded us their full co-operation and every facility for the satisfactory conduct of experimental work on their estates. I am also grateful to the many Superintendents who have furnished me with the information asked for or given me the opportunity to study specific problems on the spot.

Reference

Visser, T. (1960.) Plucking practices in relation to maintenance foliage. *Tea Quart.* 31: 38-52.

REPORT OF THE AGRICULTURAL CHEMIST FOR 1960

J. A. H. Tolhurst, B.Sc.

Staff.—Mr S. W. Karunaratne assumed duties as Research Assistant at the beginning of the year, but unfortunately he resigned in December. Attempts to fill the second Research Assistant post were unsuccessful, and the division remains at a disadvantage in this respect. Messrs V. Mendis, T. C. Z. Jayman and E. O. Steuart continued as laboratory technical staff, a fourth vacancy being deferred until 1961. It is encouraging to report that the division now has the foundation of a strong analytical team, which enables our research programme to be more ambitious. Mr R. Balthazaar joined us at the beginning of the year and, together with Mr S. Samarasingham, has helped to bring the field work to a level in keeping with the laboratory strength.

During my absence on 3 months' furlough Mr C. B. Foster-Barham acted on my behalf in the Agricultural Chemistry Division.

A.—FIELD EXPERIMENTS

The existing field trials have undergone only slight modifications in treatments, details of which were given in the Annual Report for 1959 (Tolhurst, 1960). They have provided the bulk of the samples for nutritional investigations, which have again been the mainstay of the division's programme. Towards the end of the year it was possible to start plans for a new series of manurial experiments, utilising areas on St. Coombs which are to be planted with clonal tea. When tea can be planted to the requirements of a pre-arranged experimental design we can look forward to very efficient trials, free from errors which have often proved harmful to our existing trials, and capable of giving practical results within a shorter period.

1. **Low-country Manurial Experiments.**—(a) The calcium-potassium trial on Sapumalkande Estate has continued unchanged, and with no significant treatment effects. In view of the present emphasis on potash nutrition, these plots will have an added value, in comparison with other trials in the low country. Analyses of mature-leaf samples from all plots for all the usual macro- and micro-nutrients showed no abnormal features, but it is of interest to note that the manganese contents were within a reasonable range, of 400 to 1,000 p.p.m. on dry matter. Our thanks are again due to Mr E. N. Whitfield for continuing to take the yield records.

(b) The manurial trial on Endane Estate concluded the third cycle, with no significant effects to be found from any of the treatments. A tendency for the highest nitrogen level, of 160 lb. N per acre per annum, to be associated with a slight decrease in yield was observed, and a very thorough chemical investigation was started with the aim of helping to explain the lack of response to manurial treatments. Without such an explanation this trial would remain as an anomaly with regard to our present accepted ideas on manuring rates. Much of the analytical work has been completed, the results being of assistance in deciding the changes in treatments which are noted below.

Mature leaf samples were taken in February from each of the 162 plots, shortly before the completion of the cycle, and soil samples from the 0-3" layer followed the pruning. These were co-operative operations between the staff of this division and of the Low-country Adviser's Division. Analyses were divided, for the sake of convenience, between our laboratories and an overseas laboratory. Among all the macro- and micro-nutrients in the leaf samples, there was little of interest except for the manganese and potash contents. Potash figures varied from 1.5% K_2O on dry matter to 1.7% in accordance with the potash manurial treatments, but at the time of sampling many bushes throughout the trial and regardless of potash treatments were showing moderate symptoms of potash deficiency. Manganese contents in the leaf varied from 300 to over 8,000 p.p.m., with the majority in the range 4,000-6,000 p.p.m. Here the most important feature was the very obvious relation to locality, regardless of any manurial treatment. It has been shown that the two sections of the trial, each of 3 blocks, tend to lie in high and low manganese areas respectively, with the further complication that the additional calcium treatment, which had been applied on a block basis, was even more closely associated with the pattern. The three low-calcium blocks also included the greater part of the lowest manganese areas, as judged by uptake of manganese by the leaf.

Therefore it was decided to remove the differential calcium treatment entirely, as no evaluation of a calcium effect could be made under such circumstances.

Soil analyses are attempting to correlate the manganese extractable by various methods with the uptake by the tea, and to date a measure of success has been achieved. Organic soil carbon, by Jackson's modification for high-manganese soils, is high, reaching 7% in the 0-3" layer, and results so far obtained suggest that it may be positively correlated with the manganese content of the leaf.

Nitrogen levels in the leaf were high in all treatments, and varied little from 3.5%.

The general conclusion was that, on that particular soil-type, the levels of sulphate of ammonia were too high, possibly accentuating the tendency for the bush to absorb manganese. Therefore nitrogen levels were reduced to

0, 40, 80 lb. N per acre per annum.

At the same time it was considered prudent to reduce the other nutrients by one-third, viz :

40, 60, 80 lb. K_2O	} per acre per annum
0, 20, 40 lb. MgO	
Basal level of 40 lb. P_2O_5	

Further details will be found in the Report of the Low-country Adviser.

(c) A new manurial experiment has been planned for an area of TRI 2023 on Palmgarden Estate, details of which will be given in due course by the Low-country Adviser. It is hoped that this trial will answer the question of how frequently tea should be manured in the cycle, in relation to various levels of nutrients. At present nitrogen, potassium, and magnesium are to be studied.

Detailed analyses will be made on the 81 plots, but preliminary investigations have shown that the mature leaf is reasonably normal in its mineral nutrient content.

2. Passara Manurial Experiment.—It was decided that no useful purpose would be served by continuing this trial. Our thanks are due to Gonakelle Estate for having helped the Institute for so many years with the experiment.

3. Phosphate Manurial Experiment: St. Coombs No. 13 Field.—It was decided to continue with only 4 blocks of the original experiment, which were accordingly clean-pruned in July. Treatments have been modified slightly:

Basal level of nitrogen at 80 lb. N per acre per annum

„ „ „ potash „ 40 lb. K_2O „ „ „

Phosphate in two forms, superphosphate or rock phosphate, at levels of—

15, 30, 45 lb. P_2O_5 per acre per annum.

The plots lie on a sharp ridge, and the poor recovery from pruning, also seen in non-experimental tea nearby, suggests that the site is highly abnormal. Various patterns of chlorosis and scorch appeared on the young shoots, and attention will have to be given to these symptoms if we are to continue with the trial. Tipping will have to be delayed until all danger of drought has passed.

4. N. P. K. Experiment: St. Coombs No. 3 Field.—Details were given in the Annual Report for 1959 of the cultural changes made in that year, and it is only necessary here to state that the vigour of recovery from the hard pruning has been surprisingly great. Tipping, at 24", was delayed until 7 months, followed by a second tipping after a further 3 months, in June 1960. The second tipping was restricted to the centre shoots, and a ring of side shoots was allowed to grow unchecked during several of the subsequent plucking rounds. By the end of this year the cover in the better plots was very good. Plucking will continue to be hard in the centres, to encourage the side shoots still further.

Weeds have been cut down only when growth became too vigorous, and although troublesome on the potash-deficient plots with their poor cover, in the remainder the effect of the weed mulch appears to have been good. No forking has been done, but the original surface crust is no longer noticeable.

Most bushes, with plentiful exceptions in the potash-deficient plots, now carry sufficient thick young shoots to make it possible to plan a pruning to shape completely new frames, probably in 1962.

A count of potash-deficiency symptoms was made in December, recording the numbers of bushes showing symptoms regardless of their severity. Details will be withheld until accompanying analyses are completed, but it is considered worth while to mention that an appreciable number of affected bushes were seen on plots which had received 20 lb. or even 40 lb. of K_2O per acre per annum over the past thirty years, especially where the super-phosphate applications, containing soluble calcium salts, had been high. This suggests that the present exceptional vigour of growth may show up an overall shortage of potash in the present manure mixtures, and that the potash response curve may alter in the future.

B.—PLANT NUTRITION

While the established field experiments have provided ample material for investigation of mineral nutrition problems, attention has also been paid to chemical study of several chlorotic symptoms of tea and of *Gliricidia* growing in many districts. Progress has been made and the salient features are presented below.

1. Boron toxicity.—Close observation was kept on the plots in the No. 3 Field N.P.K. trial, with particular regard to the effect of the potash-calcium ratio on boron uptake (Tolhurst, 1960). In a few of the plots which had received potash but no calcium, symptoms of chlorosis and necrosis of

the lower leaves were noticed on many shoots a few months after pruning. Defoliation followed and gradually ascended the shoot until a tuft of leaves remained at the tip. In most cases the stem was slow to harden, and was sometimes quite pliable. Full chemical analysis showed that the only abnormality was provided by the boron content, which was between 80 and 130 p.p.m. in affected leaves, compared with 30 to 40 p.p.m. in comparable healthy leaves.

Boron-toxicity symptoms on large bushes in No. 9 Field had already been obtained, by applying borax to the soil, but it was not until considerable defoliation had occurred and new leaves were developing that a good resemblance could be seen to the symptoms found in the N.P.K. trial. As a further check solid borax was placed in holes drilled in newly-pruned branches, in six bushes in No. 9 Field, a total of 0.2 gm. of borax per branch being injected in two doses with a one-month interval. Within five months the developing shoots showed symptoms identical with those in the N.P.K. trial, while shoots from control branches on the same bushes developed normally. Analyses, which are not quite completed, showed between 100 and 200 p.p.m. of boron in affected leaves.

It can be presumed that boron toxicity has arisen in the experimental plots as a result of nearly thirty years' manuring with potash, with no calcium additions to the soil. At present very few bushes are severely affected, and those are mainly in one remote block of the trial. Symptoms decreased with the length of time from pruning, possibly due to the progressive dilution of boron within the increased weight of shoot growth, while the falling of the lower leaves also removed boron temporarily. It is possible that if the pruning leaf, which contained about 70 p.p.m. boron, had been removed from these areas, there would have been less risk of boron toxicity to the new shoots.

The symptoms will be illustrated in detail subsequently.

2. Iron deficiency.—Although we do not as yet attach much importance to this disorder, it is again recorded because it has been observed more frequently on St. Coombs, more particularly in two widely-separated nurseries, under different conditions, but with no apparent effect on growth. The incidence on a plot of TRI 2021 bushes, some in plucking and some growing for cuttings, has increased, and in both instances growth is exceptionally vigorous. The chlorotic symptoms have been observed during all conditions of climate, which is rather unusual for this nutritional disorder.

3. Potassium deficiency and manganese toxicity.—Probably the most interesting aspect of our nutritional investigations was the induction of potash-deficiency symptoms, covering the full range of patterns, on mature bushes by the application of manganese sulphate to the soil.

Two areas on St. Coombs were chosen for the treatments, which were applied in June and July. Four small plots in the block of TRI 2021, mentioned above in connection with iron deficiency, received either 3 or 6 ounces of dried manganese sulphate per bush, the plots being duplicated. Normal N.P.K. manuring continued. The second site was in No. 9 Field on seedling tea, the treatments here comprising 4 ounces of manganese sulphate per bush to a row of 15 bushes, and 2 ounces of sulphur per bush to a similar row nearby. Both treatments were repeated in an adjoining plot where liming had, over a period of five years, raised the soil pH to approximately 6.3 in the 0-2" layer, and 5.9 in the 2-4" layer, the bushes not having shown signs of suffering thereby. Comparable pH values in the unlimed area approximated to 4.7. Both areas had been deprived of all manure, with the exception of a magnesium-sulphate foliar spray, for one year prior to the treatments, which were applied in June.

The plots of TRI 2021 showed very slight purplish symptoms of potash deficiency (Tolhurst, 1960) after 4 months, but the picture was very different in the under-manured seedling tea. Eleven of the manganese-treated bushes on the highly acid soil showed moderate to severe potash deficiency, the symptoms including all patterns. The sulphur treated bushes in the same area had an unhealthy appearance, and showed a few suspicions of potash deficiency. No such symptoms were seen on either of the treated rows in the limed area or on any of the control bushes.

Analyses of foliage, from individual bushes, and of soil is proceeding in detail, but it is already possible to say that these pilot trials provide strong evidence in support of the hypothesis that an excessive uptake of manganese from the soil can induce potash deficiency in the tea bush. Detailed field trials will be planned, with particular regard to the relation between this nutritional imbalance and problems arising from high rates of manuring with mixtures containing sulphate of ammonia.

4. Nitrogen accumulation following pruning.—The area of No. 9 Field, already referred to under Item 3, had been pruned in July 1959 and recovery was seen to be rapid, in spite of the cessation of manuring. By November of that year it had been observed that the leaves were large and very dark green, and that some, usually near the base of the shoots, had become distorted and chlorotic. The distortion had the effect of bulging the tissues upwards between the main veins and, eventually, of causing the leaf blade to develop so markedly in the centre that the tip was curled downwards, sometimes almost back to the petiole. The chlorosis started as vague yellowish patches in the central areas of most rapid growth, and later developed into brown, necrotic patches which usually joined up and extended almost to the leaf margins. Identical symptoms were observed early in 1960 on many plots in the No. 3 Field N.P.K. Experiment, with no apparent relation to manurial treatments other than that small bushes on the potash-deficient plots showed more susceptibility. It appeared that the bushes with the least volume of tissues to absorb nutrients were here suffering most, whereas in No. 9 Field large-framed and small-framed bushes suffered equally.

Many time-consuming small-scale field trials and analyses were carried out, before the rather surprising conclusion was reached that the trouble was directly due to an excessive uptake of nitrogen from the soil, and regardless of any detectable abnormality among other nutrients. Affected leaves not only showed up to 50% more total nitrogen than comparable healthy leaves, but also a large accumulation of alcohol-soluble non-protein nitrogen. In addition, the dark, distorted leaves were consistently higher in dry matter than normal leaves. On affected shoots the youngest leaves, however, were lower in total nitrogen than on healthy shoots. Once the shoots were tipped and several buds began to develop, the symptoms lessened. Analyses of other nitrogen fractions, e.g. nitrate, ammonia, amines, cyanide, in the leaf revealed nothing of interest.

Frequent soil sampling showed that, at the same time that the rapidly-growing bushes were suffering from an excess of nitrogen, there were considerable reserves of readily extractable ammonia and nitrate in the upper soil layers, amounting to 50 lb. of nitrogen per acre in the 0-3" layer alone. It is hoped to follow up this problem as soon as possible, as it may have considerable practical importance in connection with vigorous stands of tea which may, in the pruning leaf, return 300 to 500 lb. of nitrogen per acre, much of which may become available to the roots within a few months. The size and timing of the first application of manure after pruning may have to be adjusted to allow for this sudden access of nitrogen from a vigorous stand of tea.

5. Nitrogen deficiency and new nitrogenous manures.—As a contrast to the above problem, some attention was given to nitrogen deficiency occurring in young, rapidly-growing plants of TRI 2024, a clone which seems to have a high nitrogen requirement. Qualitative experiments were done on plants running up for cuttings, using sulphate of ammonia, ammonium sulphate/nitrate, and urea, as the sources of nitrogen. Each manure was applied either as a foliar spray or as a soil dressing, early in the monsoon. Each treatment supplied a total of 1 ounce N per bush, in one application to the soil or in six applications to the foliage. All appeared to be equally effective in restoring a healthier colour and texture to the previously thin and pale yellow-green leaves.

The main purpose of this preliminary trial was to study the behaviour of the two unfamiliar nitrogenous manures, and it has been decided that urea should be included in a quantitative field trial. Where rapidly-growing clones persist in showing pale, yellowish, foliage it may be preferable to increase the dosage of the balanced young tea manure, possibly increasing the frequency of application as well, rather than to resort to special treatments with nitrogenous manures alone.

C—MANURING TRENDS

It appears that too many estates are continuing to apply over-generous rates of manure even when fields have reached a steady cropping level. This is contrary to our advice (Tolhurst, 1958), and we suggest that careful consideration of manuring programmes may be desirable. Evidence is not lacking, in our field experiments and elsewhere, that potash uptake is being handicapped in spite of apparently high replacements of potash, in company with correspondingly generous levels of sulphate of ammonia and rock phosphate. The lower elevations and parts of Uva seem more prone to this trouble.

Reducing the nitrogen application together with an increase in the potash application would seem to be one way of tackling the problem. There may even be reason to favour a return to a “pruning mixture,” perhaps with an N/K₂O ratio of 1: 1, for a critical period in the pruning cycle, and the same ratio may be desirable for districts of high light-intensity.

The position regarding rock phosphate is obscure, and there is no evidence that this form of phosphate can actually be harmful to tea when used at rates at present favoured in practice. It must be repeated that the ill effects due to the phosphatic dressings in the No. 3 Field N.P.K. Experiment can almost certainly be attributed to the readily soluble calcium contained in the *super-phosphate*, which is there used in a high ratio to the potash dressings. There would be no *harm* in restricting rock phosphate applications in practice, especially as potash deficiency has been observed on some of the highest yielding estates. An accumulation of calcium from repeated high dressings of rock phosphate could be expected to hinder the correction of potash deficiency; and a restriction of phosphate applications to 30 or 40 lb P₂O₅ per acre per annum would doubtless be quite safe, but no experimental support for such a practice is as yet available.

An additional help towards avoiding potash deficiency at high rates of nitrogenous manuring may be found in the use of a new type of “compound fertilizer” which has recently become available. Such manures can be made to various N.P.K. ratios and consist of a single ingredient in large granules. The fact that approximately half of the nitrogen is in the nitrate form may be an advantage, as it is the oxidation of ammoniacal nitrogen in the soil which is likely to accentuate manganese uptake by the tea.

In addition, the reduction of the concentration of the ammonium cation in the root zone would no doubt ease the uptake of the potassium cation, while the presence of the nitrate anion would probably assist potash uptake still further. Before this type of manure can be accepted in practice it will be necessary to test the handling properties under varied estate conditions, and attention must be paid to rational methods of application (Tolhurst, 1959). We encourage individual experimentation with such compound fertilisers.

D—GENERAL

We again extend our thanks to Messrs N. M. Sanders and S. P. Vytilingam for their continued operation of meteorological instruments on Pedro and Kirimetiya Estate.

The strengthened analytical staff has enabled us to make it worth while to purchase a photomultiplier attachment for our spectrophotometer, which will, in the coming year, increase our analytical efficiency still further.

E—PUBLICATION

Tolhurst, J.A.H. (1960). Complexities in plant nutrition and their relation to manuring practice. *Tea Quart.* **31**: 98-100.

F—REFERENCES

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Tolhurst, J.A.H. (1960). Report of the Agricultural Chemist. *Annu. Rep. Tea Research Institute of Ceylon for 1959*: 36-45.

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REPORT ON BIOCHEMISTRY FOR 1960

M. S. RAMASWAMY, B.Sc., A.R.I.C., A.I.I.Sc.

General.—There were no staff changes during 1960 and, as before, the staff consisted of two assistants and myself. I acted as Head of the Biochemistry Division for about three months between August and October, 1960.

The renovation of the laboratories was completed during 1960. Until the new buildings for the Biochemistry Division are ready, work is restricted. The restriction is expected to become more acute in 1961 when two more assistants are to be recruited.

Laboratory facilities were provided for the Research Assistant in the Technology Division for analytical aspects of his work.

RESEARCH

1. Correlation between the chemical analysis of the liquors and the liquoring properties of the teas manufactured in districts at different elevations and climatic conditions.—This investigation, initiated early in 1959, was completed by the middle of 1960. A mass of data collected was assessed for various correlations by simple statistical methods. A preliminary summary of the various significant correlations obtained is given here.

Ungraded tea samples made by orthodox factory manufacturing methods were obtained every month, for a period of 12 to 13 months, from estates situated at different elevations and under various climatic conditions. The teas were brewed for 5 minutes and the liquors were chemically assayed for the following constituents :

- (1) the soluble solids,
- (2) the mineral constituents,
- (3) the total oxidisable substances,
- (4) the acid-soluble oxidisable substances,
- (5) the free volatile organic substances,
- (6) the hydrolysable volatile organic substances,
- (7) the absorption of light,
- (8) the theaflavins,
- (9) the caffeine and
- (10) the nitrogen.

The teas were sent to eight different tasters in Colombo under code numbers for their valuation of the liquoring properties. The scheme adopted for tasting was the same as that reported by Keegel (1959), except that the quality and the character of the liquors were valued separately and the values for the grade and the appearance of the teas were ignored. It should be mentioned here that in relating the chemical constituents of the liquors to the tasters' valuations for flavour, only those teas which were produced during the flavoury season were considered. It should also be stressed that while some of the correlations found are likely to be due to a causal relationship between the chemical constituents of the liquors and the valuation for the liquoring characteristics, others may be incidental or even spurious.

Thus there are well-known differences in climate and in manufacturing practices in different regions of the Island ; these may result in differences

in liquors that are not assessed by tasters but are detected chemically. To obviate these difficulties, investigations are in hand to determine some of the inherent chemical properties of the green leaf obtained from various estates. But still there are other variations due to the different manufacturing techniques adopted in different estates to produce teas to suit different markets. Therefore, until further data are obtained from the current investigations on clonal leaf manufactured under strictly controlled conditions, the results presented here must be considered as purely tentative and subject to modification in the light of any further knowledge obtained.

1.1. Liquoring Properties.—The results indicated that there was a close inter-relationship between the quality, the character, the colour of the infused leaf and the flavour. Inter-relationships of other liquoring characteristics were found to be insignificant. In regard to the judgment of the various tasters for the liquoring properties of similar teas, the tasters generally agreed very well in their valuations of the liquors for their quality, character, colour of the infused leaf and flavour. On the other hand there was much disagreement between the tasters concerning valuation for the colour and the strength of the liquors.

1.2. The relationship between the constituents of the liquors and the valuation for various liquoring properties.—The desirable characteristics of a *high quality* tea generally appeared to be related to a *high content* (in the liquors) of (1) the theaflavins, (2) the soluble solids, (3) the total oxidisable substances and (4) the acid-soluble oxidisable substances. Since most of these constituents are related to the polyphenolic constituents of the leaf, it may be presumed that a high polyphenolic content in the leaf is an essential prerequisite for the production of a good quality tea. The desirable characteristics of a *high quality* tea were also found to be generally related to a *low content* of (1) the mineral constituents, (2) nitrogenous substances other than caffeine and (3) probably caffeine. These preliminary conclusions are useful, at any rate for the present, in restricting the chemical assessment of the experimental teas produced from clones (of known or unknown liquoring properties) for purposes of selection. On the other hand, there are certain other difficulties on account of (a) the seasonal variations in the constituents of the leaf of individual clones and (b) the effects of different conditions of manufacture on the constituents of the liquors of individual clones. The degree of withering, the type of rolling, the period and the temperature of fermentation, the humidity conditions of rolling and fermenting room, and finally firing conditions, all affect the nature of the teas produced from each clone which, in turn, affect the constituents of the liquors. However, on a very broad and rough basis, the amount of the various constituents of the liquors just enumerated, may be taken as an index of the *probability* of the quality of the made teas and for comparing the teas made from different clones with each other.

1.3. The constituents of the tea liquors in relation to elevation, season and climatic zone of the tea districts of Ceylon.—The following additional information, obtained incidentally to the results of the investigation described above, may be of interest.

(a) RELATIONSHIP BETWEEN THE CONSTITUENTS OF THE TEA LIQUORS AND THE ELEVATION OF THE TEA DISTRICTS SITUATED BOTH IN THE S.W. AND IN THE N.E. MONSOON ZONES.—The theaflavins, the total oxidisable substances and the acid-soluble oxidisable substances appeared to be *positively* (and significantly) related to the elevation; on the other hand, the mineral constituents, the caffeine and the nitrogen content of the liquors were found to be *negatively* (and significantly) related to the elevation.

(b) RELATIONSHIP BETWEEN THE CONSTITUENTS OF THE TEA LIQUORS AND THE ELEVATION OF THE TEA DISTRICTS SITUATED IN THE S.W. MONSOON ZONE ONLY.—In addition to the relationship found for the teas produced in both monsoon zones, the soluble-solids content of the liquors was also found to be positively related to the elevation.

(c) EFFECT OF THE WET AND THE DRY SEASONS ON THE CONSTITUENTS OF THE LIQUORS OF TEAS PRODUCED IN THE S.W. AS WELL AS THE N.E. MONSOON ZONES.—The theaflavins, the soluble solids, the acid-soluble oxidisable substance, the caffeine and the nitrogen content of the liquors were found to *increase* (significantly) during the dry season; on the other hand, the mineral constituents, the total oxidisable substance and the percentage absorption of the liquors were found to *decrease* (significantly) during the dry season.

(d) EFFECT OF THE WET AND THE DRY SEASONS ON THE CONSTITUENTS OF THE LIQUORS OF TEAS PRODUCED IN THE S.W. MONSOON ZONE ONLY.—The soluble solids, the caffeine and the nitrogen content of the liquors were found to increase (significantly) during the dry season while the mineral constituents decreased significantly. The degree of increase in the caffeine content during the dry season was found to be higher at lower elevations than at higher elevations, probably due to a higher rate of metabolism in the tea bush at lower elevations.

1.4. *Summary.*—Summarising the results of the additional (but incidental) information obtained, it appeared that the theaflavins and generally the polyphenolic constituents of the liquors were found to a *larger* extent in the teas produced at *higher* elevations than those produced at lower elevations, while the mineral constituents, the caffeine and the nitrogenous constituents of the liquors were found to be *higher* in the teas produced at *lower* elevations, than in those produced at higher elevations. The theaflavins, the caffeine and the nitrogenous substances were found in the liquors to a larger extent during the dry season than in the wet season while the mineral constituents of the liquors increased during the wet season.

2. **Clonal Leaf**—Investigations are being carried out on different T.R.I. clones of known manufacturing properties (Keegel, 1959) with a view to determining the variations in the constituents of these clones in relation to their quality. The work is confined, at any rate for the present, to the clones propagated at St. Coombs and to the determination of: (1) the individual, but more important, polyphenolic constituents of the green leaf; (2) the fermenting properties of the clones; and (3) the theaflavins, soluble solids, caffeine and the nitrogenous compounds (other than caffeine) in the liquors of made tea manufactured under standard conditions by the mincing technique. The work is still in a preliminary stage and will be continued during 1961. However, the results so far obtained from the preliminary investigations and the tentative conclusions drawn are briefly indicated below.

2.1. *The more important individual polyphenolic constituents of the T.R.I. clones belonging to different quality groups.*—For a start the one-way and the two-way paper partition-chromatographic methods were applied for the separation of the individual polyphenolic constituents and to examine the more important constituents viz. the gallo catechins, the gallo catechin gallates and the *epi*-catechin gallate. No large differences in the content of these polyphenols between the various clones tested were found to occur. Further, the separated constituents could not be quantitatively assessed by the available methods. Column-chromatographic methods using cellulose powder (Whatman ashless powder for chromatography) was also used for the separation of various constituents of the aqueous extract of the green leaf. The process of separation was very slow. The fractions obtained were determined by oxidation with chromic acid. Here again there were large differences even between

duplicate estimates. It is expected to obtain an automatic fraction collector during the coming year when further attempts would be made to standardise this method for the quantitative assessment of various fractions obtained from a column-chromatographic apparatus, using different absorption or partition media.

2.2. Fermenting properties of the T.R.I. clones belonging to different quality groups.—Withered leaf, minced and fermented for various periods, was examined (in a Beckman spectrophotometer using the reflectance attachment) for the absorption of light at different wave lengths. The results indicated slight differences between various clones tested, but these differences were not large enough for a significant differentiation. Further work is in progress to standardise the conditions of examination and to evaluate the fermenting properties of various clones.

2.3. The theaflavins and the soluble-solids content of the liquors from the experimental teas (made by the miniature technique).—Preliminary investigations were carried out with clonal leaf with a view to standardising the conditions to obtain a constant degree of wither under laboratory conditions and also to obtain the optimum conditions for firing the fermented material in a specially constructed miniature drier. Clonal leaf was withered, as nearly as possible to a moisture level of 55% in the leaf in all the experiments carried out, unless stated otherwise. Naturally the time taken to wither the leaf varied according to the external weather conditions. The withered leaf was minced and fermented in a humid atmosphere for exactly 240 minutes and fired in the miniature drier for 30 minutes under identical conditions. The moisture content of the made teas were found to vary between 3% and 5% in the finished product.

Preliminary results indicated that the soluble-solid content of the liquors from a set of clones plucked on any particular day was generally found to be related to the quality group to which the clones belonged; on the other hand, the results of the theaflavin content of the liquors were found to be not consistent. Further data are being collected.

2.4. The theaflavin and the soluble-solids content of the liquors of the teas made from clone TRI 2024 in relation to the degree of withering.—The results of the preliminary experiments are presented in Table 1.

TABLE 1.—*The theaflavin and the soluble-solids content of the liquors in relation to the degree of withering.*

(The theaflavin content is expressed in arbitrary but comparable units while the soluble-solids content is expressed in mg in 30 ml of the liquors)

Leaf plucked on 2.10.60			Leaf plucked on 2.11.60		
% moisture in the withered leaf.	Soluble solids	Theaflavins	% moisture in the withered leaf.	Soluble solids	Theaflavins
67	151.2	1.83	69	140.3	1.59
65	147.2	1.63	65	139.0	1.08
60	152.7	1.41	60	137.9	0.94
57	153.0	1.13	55	141.2	0.63
54	159.5	1.12	50	138.7	0.59

The theaflavin content of the liquors decreased as the degree of the wither increased, all other conditions of the manufacture being constant. Its content in teas manufactured from the same clone and withered to the same extent but plucked at different intervals appeared to be different. The results of the soluble solids on the other hand showed only an uncertain tendency to change as the degree of the wither increased. Further data are being collected.

2.5. The theaflavin and the soluble-solids content of the liquors of the teas made from clone TRI 2024 in relation to the period of fermentation.—The results of the preliminary experiments are presented in Table 2.

TABLE 2—*The theaflavin and the soluble-solids content of the liquors in relation to the period of fermentation*

(Results are expressed as in Table 1)

Period of fermentation (min.)	Leaf plucked on					
	9.11.60		16.11.60		21.11.60	
	Soluble solids	Theaflavins	Soluble solids	Theaflavins	Soluble solids	Theaflavins
0	—	—	176.8	0.35	—	—
30	—	—	170.2	1.28	168.4	1.11
60	169.5	1.43	169.8	1.55	158.9	1.12
120	160.8	1.13	150.5	1.42	150.8	0.99
180	152.8	0.95	145.7	1.19	156.7	0.88
240	147.1	0.80	—	—	141.7	0.71
300	145.2	0.68	—	—	—	—

As the fermentation progressed, the theaflavin content appeared to increase to a maximum level in about 60 min. of fermentation, and then gradually decreased. On the other hand, there was a progressive fall in the soluble solids content as the period of fermentation increased. Even though the amount of theaflavin varied in the teas manufactured from different plucks, the maxima appeared to occur at a definite period viz. 60 min. of fermentation. Further data are being collected, and if the above results are confirmed, there appears to be at least one constant in the conditions of manufacture for any individual clone, viz. the period of fermentation for the maximum production of the theaflavins. Temperature was not controlled but was reasonably constant around 20° C (68° F).

2.6. The total nitrogen content of the liquors of the experimental teas made (by the miniature technique) from T.R.I. clones belonging to different quality groups.—Results of preliminary experiments showed no marked relationship between the total nitrogen content of the liquors and the quality group to which the clone belonged.

(a) THE CAFFEINE AND THE NON-CAFFEINE NITROGEN CONTENTS OF THE LIQUORS OF THE EXPERIMENTAL TEAS MADE (BY THE MINIATURE TECHNIQUE) FROM T.R.I. CLONES BELONGING TO DIFFERENT QUALITY GROUPS.—The caffeine and the non-caffeine nitrogen contents of the liquors from the high-quality clones generally appeared to be lower than from the poor-quality clones. Further data are being collected.

(b) THE CAFFEINE AND THE NON-CAFFEINE NITROGEN CONTENT OF THE LIQUORS OF THE TEAS MADE FROM CLONE TRI 2024 IN RELATION TO THE DEGREE OF WITHER AND THE PERIOD OF FERMENTATION.—The caffeine content of the

liquors appeared to increase as the degree of wither or the period of fermentation increased. The increase in the caffeine content due to the increased degree of wither confirms the findings of Wood & Chanda (1957) who showed an increase in the caffeine content of the withered leaf when green leaf was withered under natural conditions for approximately 24 hours. The results of the increase in the nitrogen content (other than caffeine nitrogen) were, however, not consistent. Further data are being collected.

2.7. Summary.—Summarising the results of the preliminary investigations on the experimental teas manufactured (by the miniature technique) from the clonal material, the following tentative conclusions could be drawn. The total soluble-solid content of the liquors appeared to be positively related to the quality group to which the clone belonged. The caffeine and the nitrogen content of the liquors also generally appeared to be related, but this time inversely, to the quality group to which the clone belonged. The caffeine content of the leaf appeared to increase during the withering and the fermentation processes and this is probably due to the caffeine-synthesising enzyme in the leaf remaining still active during these processes.

2.8. General remarks: biochemical differences between clones.—Incidentally to the results obtained from the above investigations, which were carried out for a different purpose, it was found that the nitrogen content of the liquor of the tea manufactured from any individual clone showed a tendency to be constant irrespective of the date of plucking. This indicates the possibility of the soluble-nitrogen or the total-nitrogen content of the flush also being constant. Further work has to be carried out to confirm this finding. If the results are confirmed the method could be used for the biochemical differentiation between clones. It is not out of place to mention here that earlier work in this Division (unpublished) appeared to indicate a general constancy in the chlorophyll content of the maintenance leaf in a clone; details of this, together with the data of investigation on the chlorophyll content of up-country Ceylon teas are being prepared for publication in the *Tea Quarterly*.

3. Instant Tea.—Preliminary investigations were carried out on the rate of absorption of moisture by a number of commercial and experimental soluble products and two grades of black tea, kept under various humidity conditions.

4. Miscellaneous.—**4.1.** A deposit on the roof of a factory over the drier was examined for its caffeine content.

4.2. A commercial sample of tea was examined for possible adulteration.

ACKNOWLEDGMENTS

Once again, we wish to acknowledge gratefully the help of several tasters in Colombo for tasting the tea samples and the Superintendents of various estates who provided us with the samples of black tea.

PUBLICATIONS

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- RAMASWAMY, M. S. (1960). Biochemical studies on the organic matter in Ceylon tea soils. Part I. Soil organic matter. Part II. Mineralisation of soil organic nitrogen under controlled laboratory conditions. *Tea Quart.* 31: 136-152.

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- WOOD, D. J. & CHANDA, N. B. (1957). Indian Tea Assn. Report of the Biochemical Branch. *Annu. Rep. Tocklai Expt. Sta. for 1956*: 124-132.

REPORT OF THE ENTOMOLOGIST FOR 1960

J. E. CRANHAM, B.A., D.I.C.

A. General.—Mr W. Danthanarayana was appointed as a Research Assistant and joined the staff on September 10th. He then joined Dr Judenko's team until the end of the year for initial training in work on Shot-hole Borer. No other changes in staff occurred.

Altogether 316 letters were received and 482 letters sent out. Estate visits by all staff of the Division numbered 208, and I made 73 visits myself. Except for 6 visits of a purely advisory nature, these visits were in connection with research work.

Acting on a resolution of the Experimental and Estate Committee at the February meeting, a Shot-hole Borer Sub-Committee was formed from planter members and T.R.I. staff, with the Director as Chairman. I convened the first meeting on May 14th.

B. Mites.—1. **Methods of Assessment.**—An improved rotary mite-brushing machine was received from the U.K., a model which works off car batteries or by mains electricity. The method of brushing mites and eggs on to a revolving circular plate or card for ease of counting was used successfully for Scarlet Mite and was a great improvement on the discing method previously used. It was also used successfully for Red Spider Mite and for Yellow Mite; for the latter a suitable method had not previously been worked out at the T.R.I. Considerable data were obtained on the distribution of Scarlet Mites on foliage, and on sampling techniques. A full analysis of these data has not yet been made.

2. **Scarlet Mite Species.**—Attention was given to the species of *Brevipalpus* on tea and shade trees. A collection of material from different estates was checked by the Commonwealth Institute of Entomology. *B. californicus* Banks (= *australis* Tucker) was found on tea and on *Albizzia moluccana*, but never on *Grevillea robusta*.

B. obovatus Donn was found only once on tea and not on *Grevillea* or *Albizzia*. *B. phoenicis* Geijskes was found mostly on *Grevillea*, but also on *Albizzia* and on tea. Further work is needed before conclusions can be reached.

3. **Predatory Mites.**—A collection of mites of a predatory type was identified by the Commonwealth Institute of Entomology. Very small numbers of *Exothorhis* sp. and *Agistemus* sp. (both Stigmaeidae) were those associated with Scarlet Mite. More commonly a *Phytoseius* sp. and four *Typhlodromus* spp. (Phytoseiidae) were associated with Tea Red Spider Mite alone or in combination with Scarlet Mite. A *Bdella* sp. (Bdellidae) was also noted with Red Spider Mite.

4. **Population Studies.**—Periodic sampling of populations of Scarlet Mite and Red Spider Mite were carried out at Gonomatava Estate, Haputale, and were started late in the year at Kirimetiya Estate, Galaha. Yellow Mite sampling was done at St. Coombs. Weather records are also being maintained. A study of the data for Scarlet Mite on No. 13 Field St. Coombs over four years confirms the marked effect of weather conditions on Scarlet Mite numbers. Mite numbers increased in dry sunny weather and were greatly reduced during

the S.W. monsoon each year according to the severity of the monsoon. Extremely few mites or insects of a predatory nature have been observed in association with Scarlet Mite, far too few to sample population trends.

5. **Chemical Control.**—The long-term trial in No. 13 Field, St. Coombs on the control of Scarlet Mite and the effect of mite damage on yield was terminated in May 1960 when the field was due for pruning. There has been no significant loss of crop due to mite attack, but the defoliation and damage due to mites was not very severe, nor was the control obtained very good. The non-tainting acaricide Chlorbenzilate (Akar) (ethyl-4, 4' dichlorobenzilate) has given results comparable to, but not better than, wettable sulphur.

At Gonomatava Estate, a trial was started in May to compare economic rates of Kelthane (1, 1-bis (chlorophenyl) 2, 2, 2-trichloroethanol), Tedion (2, 5, 4'-tetrachlorodiphenyl sulphone), Chlorbenzilate and wettable sulphur for control of Scarlet Mite. Kelthane gave markedly better control than the other treatments used. In view of the good results obtained previously with this chemical against Yellow Mite and Red Spider Mite, it is to date the most promising non-tainting acaricide against tea mites.

Also at Gonomatava, a trial to test the effect of mite damage on yield was commenced with the co-operation of the Superintendent. Yield will be pre-assessed for about one year before control measures are applied to half the plots.

6. **Effect of Copper Fungicides**—Two field trials of randomized block design were commenced to investigate the possible effect of copper fungicides on mite numbers, one on Scarlet Mite at St. Coombs and one on Yellow Mite at Ferham Estate.

The results of the St. Coombs trial up to 25.5.60 are given in Table 1. All treatments were applied at 6 oz of the formulation in 15 gallons water per acre. Captan is an organic fungicide which was included to provide blister-blight control from a non-copper fungicide; it is much more expensive than copper. The counts given for 14.10.59 represent the numbers before the different sprays were applied; treatment began in November 1959 and was continued throughout the dry weather in an attempt to produce the maximum differences.

TABLE 1

The effects of copper fungicides on numbers of mites

Treatment	Nos. of mites and eggs per 100 leaves (400 leaves sampled) on				
	14.10.59	22.12.59	12.2.60	31.3.60	25.5.60
(A) A copper oxide 50% wettable powder ..	422	1548	1966	2068	1436
(B) A copper oxychloride 50% wettable powder ..	512	1646	1889	2156	1080
(C) Bordeaux mixture ..	537	1485	1918	1701	816
(D) Colloidal copper 27% formulation ..	400	996	1239	871	482
(E) Captan 50% wettable powder ..	364	1198	1676	2091	1004
(F) Untreated ..	415	1174	1356	860	423

Analysis of variance of the log ($n + 1$) values (transformed data) show that for the data of 25-5-60, the numbers for treatments A, B and E (but not C) differ significantly ($P=0.05$) from D & F. The difference between A and C approaches significance at the 5% level, but the general trend of the data throughout this period is that only D (colloidal copper) is similar to the untreated plots.

From a practical point of view the number of mites on any treatment was not very high and the differences were not great; however, the data are of special interest since they are the first data obtained in Ceylon which confirm what many planters have long believed, namely, that the use of copper fungicides increases mites. From general observations, however, it is thought that the use of copper fungicides is only one factor conducive to a build-up in mites, and not necessarily a very important one. If the experimental differences obtained can be consistently repeated it will be possible to investigate this effect further. The result from the colloidal copper formulation requires further large-scale investigation; there is an indication that it is the type of formulation that matters, not the actual amount of copper used; but in this experiment comparisons were made between equivalent weights of formulation and not between equal weights of copper.

In the Ferham trial, the numbers of Yellow Mite have remained very low until the end of the year. Differences were not significant.

7. Effect of type of pruning and of reinfestation from shade trees.—The trial on No. 10 Field St. Coombs on the comparative effects of light and of clean pruning, both with and without sulphur spraying, on the survival of mites has been continued. In this instance, more mites survived after light pruning than after clean pruning; sulphur spraying gave a more marked reduction than clean pruning. The differences obtained on 100-bush plots have been maintained for several months, and it remains to be seen how long they will last.

Observations have continued at St. Clair Estate, comparing two adjacent two-acre plots, one with *Grevillea* shade, infested with Scarlet Mite, and the other without *Grevillea* or *Albizzia* shade trees. Whereas in January, a few months after pruning, sampling indicated almost equal numbers of mites on both plots, there were in April twice as many on the shaded plot. Numbers have been extremely low since the heavy monsoon in 1960. Interpretation of the results must involve identification of the species present on the tea and shade trees, and work is being continued.

C. Tea Tortrix.—Reported outbreaks of Tortrix over the last five years were reviewed early in the year. These were divisible into:

- (A) outbreaks occurring for unknown, but presumed natural, causes, occurring mainly above 4000 feet;
- (B) outbreaks following the use of dieldrin for the control of Shot-hole Borer, occurring in mid-country.

More outbreaks of class A have been reported in the last few years than at any time since the introduction of the parasite of Tortrix, *Macrocentrus homonae* Nixon, from Java in 1935-36 and its successful establishment by 1939-1940. Nearly all such outbreaks occurred on fields recovering from pruning into the Tortrix peak period in December-April. At worst, these outbreaks have not been so severe as some of class B, and Tortrix remains a minor pest and relatively unimportant except so far as applications of dieldrin or other insecticides may cause outbreaks by upsetting the balance between Tortrix and *Macrocentrus*. For this reason the study of 'natural' outbreaks as well as those induced by dieldrin has received particular attention.

Observations on 'natural' outbreaks were made at St. Coombs, Logie, Lindula and Mount Vernon Estates. Techniques were worked out for estimating the numbers of Tortrix and the percentage parasitized by *Macrocentrus*. The parasite usually re-established control within a few weeks, with Tortrix reduced to very small numbers and the percentage of parasitized Tortrix larvae over 80%. During the outbreak, parasitism dropped to 30–40%, by comparison with 0–5% after dieldrin spraying. Plucking is itself a partial control measure since the very young larvae are removed with the flush; the resting of fields suffering from Tortrix attack is not therefore usually advisable.

In material of *Macrocentrus* obtained from all of seven estates in the S.W. monsoon zone, a secondary pupal parasite of *Macrocentrus* was present in numbers. This was a *Calliphron* sp. and identifications by the Commonwealth Institute of Entomology showed that it was *C. fijiensis* Ferr., and that it was present in Ceylon in 1933, before the introduction of *Macrocentrus*, when it was recorded by the T.R.I. as hyperparasitic on other primary parasites of Tortrix. Data of the occurrence, life-history and behaviour were obtained.

There was no evidence whatever of a falling-off in the efficiency of *Macrocentrus*. Work so far points to the following factors as being worthy of investigation in connection with outbreaks:

- (a) climatic factors, especially heavy monsoons;
- (b) the effect of pruning in temporarily upsetting the balance, and the migration into pruned fields of Tortrix and *Macrocentrus*;
- (c) the hyperparasite *Calliphron fijiensis*.

In connection with outbreaks following dieldrin, thirty-seven estates which had used dieldrin on their own initiative were circulated with a questionnaire and it was then known that about half of the fields on which dieldrin had been used had suffered some degree of Tortrix attack, in a very few instances attack of exceptional severity lasting for up to six months. Trial work during the year involved the following:

St. Coombs Trials.—On No. 4 Field, a replicated trial with $\frac{1}{4}$ -acre plots was started in February to study the effects, of DDT, dieldrin, aldrin, and lindane sprayed on tea in plucking (flush discarded). This field had a light attack of Tortrix and was recovering after pruning in May 1959. DDT was promising for the control of Tortrix, for it reduced them to very low numbers and the parasite re-established control before the numbers could rise again. Lindane and aldrin had much less effect than dieldrin on the parasite, but only DDT gave a high initial kill of Tortrix. Dieldrin was sprayed by two methods:

- (a) as a thorough foliage spray;
- (b) to the basal frames of the bushes to a height of one foot, a method of spraying for shot-hole-borer control employed by Dr Judenko.

By both methods, dieldrin had a marked effect on the parasite; two months after spraying the percentage parasitism was for (a) 4% and for (b) 27%, compared with 81% for DDT, 57% for lindane, 50% for aldrin, and 73% for the control. Four months after spraying, parasitism was about the same for all treatments. Further evidence was obtained of the value of DDT in sprayings carried out at Logie and Lindula Estates.

On No. 5 Field, pruned in May 1960, a similar replicated trial on $\frac{1}{4}$ -acre plots was commenced in May to compare the effect of spraying DDT, dieldrin and lindane immediately after pruning and about tipping time. This trial is still in progress.

On No. 13 Field, a trial with larger plots sprayed with dieldrin was commenced in September, to carry out a detailed study of the effects on a larger scale. The field was divided into four quarters of about five acres each. Two quarters were sprayed with dieldrin and the other two left unsprayed. DDT was sprayed on half of each dieldrin plot. This trial is still in progress.

Estate Trials.—Detailed observations were made on Tortrix outbreaks following dieldrin, on larger areas at Kataboola (24 acres) and at Goorokoya (20 acres) estates, and the movement of *Macrocentrus* in from the boundaries was followed.

Following a decision by the Shot-hole Borer Sub-Committee to co-operate with estates in the design of trials with dieldrin, a simple trial design similar to that on No. 13 Field St. Coombs was adopted and the DDT was used on half the dieldrin-treated area in each case. Trials of this nature have been started on ten estates in different areas. So far, four have had Tortrix outbreaks. The use of DDT in emulsion form at 2 lb per acre has been promising for the prevention of Tortrix outbreaks, but much work remains to be completed. The situation on Sanquhar Estate, where over 300 acres have been sprayed with dieldrin, was also studied. It does not appear that the successive treatment of fields with dieldrin as they are pruned will have any permanent effects on *Macrocentrus*.

All the evidence so far suggests that *Macrocentrus* is virtually wiped out on the area sprayed with dieldrin, and that at the dosage rate used for shot-hole-borer control—about 1½ lbs. of actual dieldrin per acre—the parasite is prevented from re-entering the sprayed area for about 3-4 months. Once it can enter the edges of the field, from neighbouring tea or jungle, migration to the centre is normally rapid. In two instances only, re-establishment of the parasite was delayed for 6-9 months from spraying; this is believed to have been due to difficult climatic conditions for the parasite such as excessive drought and excessively wet weather.

D. Shot-hole Borer.—In February, a questionnaire was sent out (see above) to thirty-seven estates which were thought to have experimented on their own initiative with dieldrin applied as spray to the bush frames after pruning. It is now known that at least 1000 acres of tea had been sprayed experimentally by estates up to February 1960, the vast majority at between 1 and 2 lb. of actual dieldrin per acre.

It was decided at the February meeting of the Experimental and Estate Committee that a Shot-hole Borer Sub-Committee be formed from planter members and T.R.I. staff with the Director as Chairman. I convened the first meeting on May 14th. Acting on decisions of the meeting, work was put in hand:

- (a) to co-operate with estates in the design and assessment of estate trials on the chemical control of the pest;
- (b) to investigate methods of spraying after pruning;
- (c) to investigate the persistent toxicity of dieldrin in relation to the mode of action;
- (d) to test lindane and B.H.C. as alternatives to dieldrin.

Progress on these aspects, which are supplementary to Dr Judenko's work, was as follows:

1. Estate Trials.—Firstly, it was resolved to sample those fields that had been sprayed in 1958 by estates, to determine results after 2 years. It was in the majority of cases possible to make a comparison with the unsprayed portion

of the same field or with similar unsprayed neighbouring fields which had been pruned about the same time. Good, sometimes excellent, control was found on 5 estates, sited in Kotmale, Pussellawa, Watawala, Badulla and Passara. Poor or indifferent results were found on 5 other estates, sited in, Ginigathena, Pussellawa, Badulla, and Bandarawela. This suggested that there was no relation between the result and the district rainfall, but the weather records suggested strongly that failure was mainly due to the wood being wet at the time of spraying, an effect established in Dr Judenko's trials. However, it was stimulating to know that some estates were getting very good results.

A simple trial plan was worked out for estates and the trials were arranged by personal visits of myself and Dr Hutchinson. It is not yet possible to assess control on most of these except where new clearings were sprayed. In the latter instances, on three estates, the reduction in numbers of beetles and immature stages on the sprayed plots, compared with the control plots has so far been excellent.

2. Methods of Spraying.—An initial study was made of spray coverage obtained on pruned frames when spraying by different methods, by using fluorescent dyestuffs in the spray fluid which can be clearly seen under an ultra-violet lamp. Particular attention was given to (a) whether it is better to spray the whole of the pruned frame or to limit spraying to the basal parts, the efficacy of which has been proved by Dr Judenko; (b) the possibility of effective control from spraying low-volume by knapsack mist-blowers, employing the same dose of dieldrin applied in 5-10 gallons of water per acre. Studies on the coverage obtained using mist-blowers showed it to be good and a trial was arranged to test biological effects on both (a) and (b) on a new clearing at Aislaby, Bandarawela. Part of the results to date are given in Table 2.

TABLE 2

The course of reduction of populations of Shot-hole Borer after several methods of spraying.

Treatment (Dieldrex)	Numbers of live beetles per 100 standard units afterweeks				
	0	1 week	2 weeks	4 weeks	8 weeks
(A) 6 pints in 100 gallons of water per acre (all of pruned frame)	193	105	53	32	10
(B) 6 pints in 100 gallons of water per acre (to height of 9' on pruned frame) ..	141	155	36	25	22
(C) 6 pints in 6 gallons of water /acre (mist-blower)	143	94	27	39	25
Untreated	198	218	171	267	139

This initial trial, on duplicated plots only, shows that all three treatments have so far given very marked control, and more critical experiments are required to determine any real differences.

It is however apparent that low-volume treatment has given a promising result. Larger areas have been treated by mist-blower at Uva Ketawella and Meddetenne Estates.

3. **Persistent toxicity and mode of action of dieldrin.**—Knowledge of the way in which dieldrin controls Shot-hole Borer and particularly of the time it takes for the full effect to be exerted, is important in the design of control measures. It has been found that a large part of the kill is obtained within the first few weeks and the data given above in Table 1 illustrate this point, which is also substantiated by results from other trials and by data obtained by Austin as far back as 1954.

A trial was carried out in which bushes were sprayed in the field, different plots being sprayed at regular intervals, and finally pieces of bark with dieldrin deposits aged from 0 to 12 weeks were removed; to these, batches of mature female Shot-hole Borers were exposed in a constant-temperature room. The technique has not to date given satisfactory results and further work is required. A trial has also been started which will involve artificial reinfestation with infested prunings in the field simultaneously on plots 0 to 12 weeks after spraying. Work is being continued.

4. **Toxicity of Lindane and BHC.**—BHC and lindane (gamma BHC) formulations are of particular interest, because this insecticide appears to upset *Microcentrus* much less than dieldrin. A comparison was made in one trial between equal dosage rates of a 20% lindane E.C. and a 20% dieldrin E.C. Lindane showed much less persistence and gave inferior results to dieldrin when both were applied once only. Further experiments with two applications are indicated. Large plots were treated with lindane in an estate trial at Imboolpittia, and areas treated with BHC wettable powders are under observation at Sanquhar Estate.

E. White Grubs.—(Chafer-Beetle Larvae).—Work was continued on the identification and rearing of the larvae of some White Grub species found in new clearings and nurseries; no previous information on these Ceylon species exists. A collection of more than 20 species of adult chafer beetles in the T.R.I. collection was kindly checked by Mr E. B. Britton of the British Museum of Natural History.

Towards the end of the year it was clear that one particular species of White Grub, which can be easily identified, was most commonly associated with severe damage to young tea in new clearings and nurseries, at least in the Dimbula and Kandapola districts. Two or more other species are often numerous but seldom cause serious damage. The injurious species is believed to be *Holotrichia disparillis* Arr. but proof of this identity can only be obtained by rearing larvae through to adults; work is in progress. Field observations so far suggest that this species has a one-year life cycle with an adult emergence period between March and May.

Two replicated field trials were carried out on chemical control with aldrin and BHC. In one trial in the Kandapola District the species involved is that believed to be *H. disparillis*. Treatment with aldrin at 3 lb. per acre at the time of planting was not successful and large numbers of young grubs developed. Further treatments were applied by the Superintendent, by various methods, until by October about 28 lb. of actual aldrin per acre had been applied. White Grubs were still causing serious damage and effective control from this dosage was not obtained. Losses averaged about 20% of the plants dead and many others badly damaged over the two acres of new clearing.

The only possible conclusion that can be reached is that this species is naturally resistant to aldrin, to a degree hitherto unrecorded in the world for a species of White Grub, as far as I have been able to ascertain. Fourteen times as much aldrin as is normally effective for most White Grub species (2 lb/acre) gave certainly less than 50% control.

A satisfactory chemical control for this species has not yet been found; preliminary tests with other insecticides were carried out towards the end of the year, but it is too early to reach conclusions. A large proportion of the grubs can be destroyed by thorough digging-over of the top six inches of soil and collecting by hand; this costs less than any chemical treatment showing promise so far, and two estates have resorted to it.

In the second trial, very large numbers of a species believed to be *Anomala mundissima* were present. Good control was obtained from both aldrin and BHC at dosage rates of 2-4 lb. per acre. There were, however, no deaths of young plants on the untreated plots and damage appeared to be negligible.

Attention is being given to the problem in nurseries as well as in new clearings.

F. Nettle Grubs.—Two large-scale estate trials on the use of DDT for controlling the common Fringed Nettle Grub were carried out in Uva. DDT gave excellent control at 1 lb. of actual DDT per acre and this was successfully applied in 50 gallons of water per acre by ordinary knapsack sprayers, and in 6 gallons of water per acre employing a motorised mist-blower. This work has been reported in detail in the December *Tea Quarterly*.

G. Leaf-Hopper Studies.—In view of the fact that any likely insect vector of Phloem Necrosis disease would be a leaf-hopper species, the occurrence of leaf-hoppers at certain high-elevation estates was studied by the use of chrome-yellow coloured sticky traps, of a design recommended by Dr Hutchinson. Traps have been run at St. Coombs (4,500 ft.), Court Lodge (6,000 ft.) and Oliphant (6,500 ft.). Insect material has kindly been checked by Dr Oman of the U.S. Natural History Museum, in case it comprised two or more outwardly similar, but distinct, species. He reported one species only—*Volturnus ornatus* Dist.—previously recorded in Ceylon, which comprised over 99% of the catch. Analysis of the leaf-hoppers trapped over a period of 12 months is still proceeding.

H. Insecticide Residue Work.—With the collaboration of the Tropical Products Institute, London, in carrying out chemical analyses, work on DDT residues in made tea was continued. Complete data are not yet available.

I. Publications

The following papers were published:—

CRANHAM, J.E. (1960). The Mite Pests of Tea: A Review. *Tea Quart.* **31**: 1-7.

CRANHAM, J. E. and Fernando, E. F. W. (1960). The Biology and Control of Fringed Nettle Grub. *Tea Quart.* **31**: 156-164.

FERNANDO, E. F. W. (1960). Storage and transmission of *Ambrosia* fungus in the adult *Hyleborus fornicatus* Eichh. (Coleoptera Scolytidae) *Ann. Mag. nat. Hist. Ser. 13*, **2**: 475-480.

J. Acknowledgments.—A very great deal of help and co-operation from the Superintendents of estates is most gratefully acknowledged. Without this help, the developments in work on Shot-hole Borer and Tea Tortrix would not have been possible.

REPORT OF THE ENTOMOLOGIST (SPECIAL RESEARCH ON SHOT-HOLE BORER) FOR 1960

E. Judenko, Ph.D.

1. **General.**—The team consisted of two Technical Assistants (one of whom joined in June, 1960), four Field Attendants, a driver, and myself. From October till December, Mr W. Danthanarayana, a Research Assistant of the Division of Entomology, was also working with the team.

The laboratory and headquarters of the staff was, as previously, at Milla-witiya Estate near Ratnapura, but the work on Shot-hole Borer (*Xyleborus fornicatus* Eich.) was conducted mainly in other estates in the mid-country, about 220 days being spent away from Millawitiya.

2. **Dieldrin spraying of the basal parts of tea bushes in plucking. Dieldrin residue on made tea.**—In September 1959, a large-scale experiment was done at Dickwella Estate, when tea bushes in plucking were sprayed to a height of 12" above ground level with 1.1 lb. of active ingredient of dieldrin per acre (Judenko, 1960). Tea was plucked on the next day and a sample of manufactured tea from this experiment was sent to Shell International Company for examination regarding dieldrin residue. The result of the examination, received in March, 1960, was a dieldrin residue of one tenth part per million.

No practical recommendation emerges from this experiment.

3. **Dieldrin spraying of the basal parts of tea bushes soon after pruning.**—Six experiments were begun in 1960 and they are described in the Table 1.

TABLE 1. *Experiments begun in 1960 on dieldrin spraying against Shot-hole Borer*

Experiment No.	Estate	Experimental area in acres	Dieldrin dosage lbs/acre*	Date sprayed 1960	Age in years
1/60	Hantane	4.8	5.1	29/2—4/3	35
7/60	Kirimetiya	1.28	2.3	15/3	ca. 20
13/60	Bandarapola	1.28	2.8	22/4	40
16/60	Ryc	35.38	1.6	10/9—16/9	11
17/60	Queenstown	37.92	1.7	22/9—4/10	38
18/60	Demodera	27.15	1.6	12/10—17/10	51

*On the basis of 2500 bushes per acre, except in experiment No. 16/60, where the number was 3400 p.a.

(a) **Layout of the Experiments.**—EXPERIMENT No. 1/60.—Six randomized blocks, each consisting of 4 plots. Total number of plots; 12 treated and 12 untreated.

EXPERIMENT NOS. 7/60 AND 13/60.—Four randomized blocks, each block consisting of 4 plots. Total number of plots; 8 treated and 8 untreated.

EXPERIMENTS NOS. 16/60, 17/60 AND 18/60. Each of these experiments occupied either the whole of or the greater part of a field and the experimental area was divided into four parts. For 7-8 plucking rounds before pruning, the yields for the four parts were weighed separately. After pruning, two opposite quarters were left as controls and the other two were to be sprayed with dieldrin. Each dieldrin-spraying plot was to be divided roughly into two halves, one of which would be sprayed with DDT on the foliage against Tortrix.

At Rye and Queenstown the sprayings were carried out as designed, but at Demodera, rain interfered and the design was not achieved.

(b) General remarks on the dieldrin sprayings.—High dosages of dieldrin in the first three experiments were used in order to find the maximum effect on the yield of tea. All dieldrin sprayings were carried out soon after pruning and before bud-break, except in experiment No. 17/60, when spraying was done at the beginning of bud-break. All dieldrin sprayings were carried out up to a level of 12" above the ground and in dry conditions, i.e. when the woody parts of the bushes were dry (Judenko, 1960).

(c) Influence of dieldrin sprayings on shot-hole-borer populations.—Examinations carried out at Hantane, Kirimetiya and Bandarapola in November, i.e. 7-8 months after pruning and spraying, showed that only very small numbers of beetles were found on the control plots, and none or almost none on the treated ones. The same occurred in the three remaining experiments, when examinations were carried out monthly after sprayings.

(d) Influence of dieldrin sprayings on Tea Tortrix populations.—(i) EXPERIMENTS NOS. 1/60, 7/60 AND 13/60.

Examinations were carried out monthly, except in September. The highest population found was at Hantane in August, i.e. 6 months after spraying, when the pest appeared at the rate of 64 caterpillars per 100 treated bushes and at the rate of 15 caterpillars per 100 control bushes. Numbers of caterpillars in this experiment in November and December were very low. The populations of Tea Tortrix at Kirimetiya and Bandarapola were always lower than at Hantane.

(ii) EXPERIMENTS NOS. 16/60, 17/60 AND 18/60.

Examinations were done monthly and the highest population found was at Queenstown in December, when caterpillars appeared at the rate of 82 caterpillars per 100 treated bushes and at the rate of 6 per 100 control bushes.

(e) Influence of dieldrin sprayings on the weight of green leaf.—Yields of 11 pluckings were examined at Hantane from July till December and yields of 10 pluckings were examined both at Kirimetiya and at Bandarapola from August till December. No significant differences appeared between the weights of green leaf from treated and control plots and indeed differences were not to be expected so early in the pruning cycle.

(f) Influence of dieldrin spraying on taint and on the liquoring properties of the manufactured tea.—These points were investigated in experiment No. 1/60 only. The experimental area was pruned on 22nd-29th February, and sprayed from 29th February till 4th March, i.e. before budbreak. First tipping was done 82 days after spraying; rainfall between spraying and tipping was 20.17". The second tipping was done 103 days after spraying and the corresponding rainfall was 25.3".

All tipped leaf from treated and control plots of these two tipplings were manufactured by the Technologist of T.R.I. who reported that the made tea

was free from taint, and showed no difference from the control as regards liquoring properties.

(v) **Influence of dieldrin spraying on dieldrin residue of made tea.**—This point was also investigated for experiment No. 1/60 only. Samples of treated and of untreated manufactured teas obtained from the first tipping of this experiment were sent to the Shell International Company in England for examination for dieldrin residue ; a residue of dieldrin of 0.08 parts per million was found.

(h) **DDT Spraying.**—DDT spraying was carried out in 1960 at Rye Estate only, on 8.84 acres on 9th and 10th November, at the rate of 1.9 lb. of active ingredient per acre.

No practical recommendations emerge from the experiments described.

4. Small-scale experiment on spraying of insecticides on the soil surface of tea land.—The results of these sprayings, done in 1959 (Judenko, 1960a), were not consistent, so a further experiment was done in 1960, applying some insecticides in large amounts (see Table 2).

Insecticide	Active ingredient in lbs per acre	% reduction of beetles inside the branches of the tea
Dieldrin	6.1	54
Aldrin	7.1	56
Heptachlor	5.8	62

The insecticides were sprayed on the soil surface for about 1½ ft. round the bushes of tea in plucking. The soil and woody parts of bushes were dry during the spraying, and no rain fell on the day of spraying. Examinations were done 129 days after spraying, and the rainfall between the day of spraying and the day of examination was 31.52."

Conclusion.—In spite of the large amounts of chemicals used in these soil sprayings, reductions of beetles inside the branches were lower than those obtained by spraying with 1.1 lb. of active ingredient of dieldrin per acre applied to the lower parts of the tea bushes (Judenko, 1960). Spraying the soil seems to be a method that it is not worth while investigating any further.

5. Possibility of the infestation of tea by Shot-hole Borer from *Albizzia moluccana*.—It appeared from the previous investigations that among several species of shade trees examined, the most heavily infested by Shot-hole Borer was *Albizzia moluccana* Miq. (Judenko, 1960a).

In order to find out if the beetles from *Albizzia moluccana* are able to infest tea, the following experiment was done on the laboratory verandah, using four tea bushes of the same age after planting and pruning, growing in barrels. No open galleries could be found on these bushes before the experiments were begun.

One of these bushes was artificially infested with 1000 beetles obtained by dissection of branches of *Albizzia moluccana*, another two were infested with 1000 beetles obtained by dissection of tea prunings, and the fourth one was left as control. At about 2½ months after this artificial infestation, all bushes were dissected; no open galleries or inmates were found in the control bush,

44 open galleries and 11 live inmates were found in the two bushes infested with beetles obtained from tea prunings, and 101 open galleries and 105 live inmates were found in the bush infested with beetles obtained from *Albizzia moluccana*.

It is therefore evident that Shot-hole Borer from *Albizzia moluccana* can infest tea and breed in it.

REFERENCES

- JUDENKO, E. (1960). Further small-scale field experiments on the chemical control of attack by Shot-hole Borer (*Xyleborus fornicatus* Eich.) on tea in plucking. *Tea Quart.* 31: 19-25.
- JUDENKO, E. (1960a). Report of the Entomologist (Special Research on Shot-hole Borer) for 1959. *Rep. Tea. Res. Inst. Ceylon*: 56-58.

REPORT OF THE NEMATOLOGIST FOR 1960

M. T. Hutchinson, Ph.D.

Staff.—Mr M. K. Vythilingam completed an 8-month study tour of ten agricultural experiment stations in the United States, Hawaii, and Japan, consulting and working with nematologists. Mr R. A. Jayatilleke resigned in August, and was replaced in September by Mr P. Sivapalan as Research Assistant.

General.—The division carried out analyses for nematodes on 1,011 experimental and 1,121 estate samples; 258 letters were received and 358 were despatched; 75 visits were made to estates. The processing of estate samples was transferred from the division to the following companies in Colombo: Messrs A. Baur & Company, The Colombo Commercial Company, and Messrs Harrisons & Crosfield.

Projects.—(a) Resistance and tolerance to the Meadow Nematode (now known as *Pratylenchus loosi*, instead of *P. coffeae*).

1. TESTS AT ST. COOMBS.—Yields of clones growing in the infested field plots were similar to those reported for 1959.

A third evaluation of selected clones in the pot test showed that the following clones remained resistant even though they had been reinoculated with Meadow Nematodes from St. Coombs in July 1959: DK 8, DK 10, DT 95, M 18, M 208.

TABLE 1.—*Flowering of clones in pots as related to susceptibility to Meadow Nematode*

Clone	Average number of nematodes per 100 gm. soil (1)			Susceptibility	Flowers and buds (2)	
	1958	1959	1960		Infested	Uninfested
TRI 2022	115	186	251	Susceptible	151	10
TRI 2023	133	278	63	"	97	26
TRI 2026	837	253	205	"	34	0
TRI 2120	148	299	—	"	120	90
DK 48	59	128	—	Tolerant	140	135
K 145	75	102	14	"	11	2
TRI 2025	247	320	241	"	87	61
K 150	238	138	118	"	390	68
DK 1	16	53	350	"	65	0
DK 16	15	54	82	"	93	7
DK 69	30	30	75	"	24	5
M 3	10	39	21	Moderately resistant	8	7
M 18	9	30	21	"	101	63
DK 10	1	0	1	Highly resistant	118	152
DT 95	5	15	4	"	20	0
M 111	17	26	24	Hyper-sensitive	53	140
M 208	2	5	18	"	68	56

(1) Soil samples taken August-November 1958, February-April 1959, February-March, 1960.

(2) Totals for 5 plants infested and 5 plants uninfested, respectively. Counts made 28 April, 1960.

Infested and uninfested plants of selected clones were also examined for extent of flowering. Buds and flowers were counted and the totals for the 5 infested and the 5 uninfested plants correlated rather well with the degree of resistance or tolerance shown by these clones; that is to say, susceptible clones flowered excessively when infested, compared with either tolerant or resistant clones (see Table 1).

Recovery after pruning was estimated for infested and uninfested plants of 12 clones.* Taking into account the relative thickness of wood producing the new shoots, infestation retarded recovery in clones DK 25, DT 95 and M 111, and stimulated recovery in clones K 145 and M 214. For uninfested plants, most rapid recovery was shown by clones DK 25, DT 95 and K 145. Least rapid recovery was shown by clones DK 1 and DK 10.

A check on supposedly uninfested plants of 5 clones selected at random showed that 24 of 25 examined were free of Meadow Nematodes.

Photographs were taken of infested and uninfested plants of susceptible, tolerant, resistant and hyper-sensitive clones. Plants of several resistant and hyper-sensitive clones were transferred to No. 12 nursery as a source of cuttings. The remainder were thoroughly fumigated and the plants destroyed by burning. This pot experiment has, therefore, been terminated after a period of 5 years.

A second series of pot tests is being prepared, in order to test selected clones for resistance to 25 different populations of Meadow Nematode. For this purpose a survey was conducted of 25 estates infested with Meadow Nematode. These were selected so as to be representative of all areas known to have heavy infestations. Soil samples were taken, and one location on each estate has been selected as a source of soil for the experiment, which will be initiated early in 1961.

2. TESTS AT OTHER ESTATES.—During the year, evaluations for Meadow Nematodes and general growth of clones were made at the plots on Dambattenne, Diyanilakele, Kirimetiya and Mooloya Estates. Two evaluations for growth were made at each location. Evaluation for nematodes was made twice at Dambattenne and Kirimetiya and once at Diyanilakele and Mooloya. Clone K 145 made good growth at Dambattenne and outstanding growth at all other locations, including the field plots at St. Coombs, despite rather heavy infestations. This confirms results of the pot test at St. Coombs, wherein this clone was shown to be markedly tolerant to Meadow Nematode. Clone DT 95 made moderately good growth at Dambattenne and good to very good growth at the other locations, including St. Coombs and Drayton. Numbers of Meadow Nematodes found around the roots of this clone were generally very low. However, on Drayton Estate, 3 out of 7 samples from around roots of this clone contained moderately high numbers of Meadow Nematodes. Clone TRI 2025, although rather heavily infested, made very good growth at Dambattenne, in marked contrast to TRI 2024, which was very heavily infested and showed fair to poor growth. Clone TRI 2025 made moderate to good growth at other locations including St. Coombs. No other clones planted out in the multiplication plots at these four estates merit special comment at this time.

An additional test was initiated at Mooloya Estate during 1960. Basket plants of 55 clones were set out in a randomized design at each of two locations infested with Meadow Nematode. Of the clones under test, 49 were originated on Mooloya Estate and the remainder include TRI 2024, TRI 2042, TRI 2045, DK 8, DT 95, and K 145. A total of 1200 plants is involved. The experiment is proceeding nicely and will be evaluated during 1961.

*DK 1, DK 2, DK 10, DK 16, DK 25, DT 95, K 145, M 111, M 208, M 214, TRI 2022 TRI 2120.

3. **LABORATORY TESTS.**—Several series of tests have been carried out during 1960, using young cuttings growing inside Petri dishes. Clones that have shown resistance were compared with the susceptible TRI 2024, as regards ability of the Meadow Nematodes to penetrate, mature, and multiply in the roots. The nematodes used were taken from two areas on St. Coombs Estate. Difficulty was experienced in achieving good growth of TRI 2024 in the dishes, although most other clones grew well. Inoculation of the roots and staining of the roots to reveal the nematodes has also required experiment to determine the best procedure. Although this method of testing therefore requires refinement, we can report several preliminary results. Clone DT 95 resists entry of larvae from No. 9 Field, St. Coombs. However, it does not resist entry of larvae and adults taken from an area about 100 yards distant. Clone TRI 2135 resists entry of larvae and adults from No. 9 Field. In the case of clone DK 8, adults and larvae apparently enter, deposit a large number of eggs, and then leave the roots.

Future tests will be conducted with a single population from St. Coombs, using standardized techniques of inoculation, maintenance of plants, and staining, in order to determine the different types of resistance in tea clones.

(b) **Influence of organic matter on populations of Meadow Nematode.**—1. **POT TESTS.**—These were evaluated as to growth of plants and infestation by Meadow Nematode. Treatment with either compost or raw cattle manure did not appear to have lowered the number of nematodes or to have appreciably increased the growth of plants beyond that of the controls at the end of 18 months. One reason for this may have been the extreme variability in original size of the plants and the degree to which they were infested at the beginning of the experiment.

2. **FIELD EXPERIMENT (ST. COOMBS).**—After one year's trial, compost did not have any appreciable effect on the growth of infested basket plants set out in a small clearing. The plants have not yet been evaluated for numbers of Meadow Nematodes present.

3. **FIELD EXPERIMENT 2 (ST. COOMBS).**—An experiment was initiated in late October, to determine whether treatment with compost, Nemagon (fumigant) granules, or both of these together would assist the growth of healthy basket plants set out into infested soil from which old tea had just been uprooted.

4. **FIELD EXPERIMENT 3 (FERHAM).**—Eight months evaluation of the trial in which compost at the rate of 20 tons per acre was raked over two $\frac{1}{2}$ -acre blocks of mature tea that had just been deep-forked showed no appreciable difference in the population trend of Meadow Nematode from that in similar untreated blocks. There was a sharp but temporary rise in the number of saprophagous nematodes (those feeding upon bacteria and possibly compost directly) in the treated plots, but no appreciable difference in the populations of other nematodes. In all plots the numbers of saprophagous nematodes were considerably greater than the total of all plant parasitic nematodes, which in turn were much greater than the populations of predaceous nematodes (those feeding upon nematodes and other small animals in the soil). The experiment will be continued with modifications.

(c) **Influence of Marigolds on Populations of Meadow Nematode.**—1. **TEST AT ST. COOMBS.**—Tea growing on infested soil continued to have much better growth when interplanted with marigold. The experiment was discontinued.

2. **TEST AT ST. COOMBS.**—An experiment was initiated to determine the effect of age of marigold plants on their ability to kill Meadow Nematodes. Successive sowings of marigold seeds at monthly intervals produced plants of 3 to 7 months of age. The plants 7 months of age had nearly finished flowering

when the experiment was begun. Treatments were replicated three times. All pots containing marigolds, as well as a series of pots containing only soil, were infested with approximately 2000 Meadow Nematodes per pot.

After two weeks the marigolds were lopped at ground level, and basket plants of Clone TRI 2024 were planted to determine the numbers of live nematodes remaining in the soil. The experiment will be evaluated early in 1961.

3. TEST AT GREAT WESTERN ESTATE.—Evaluation in June 1960 confirmed the results of the January sampling already reported in the Annual Report for 1959. The test was discontinued.

4. TEST AT HOLYROOD ESTATE.—Evaluation was carried out in June. Too few Meadow Nematodes were present in all plots to allow any conclusions to be drawn. The test was discontinued.

5. OBSERVATIONS ON EFFECT OF MARIGOLD GROWING IN INFESTED TEA ON OTHER ESTATES.—In the course of visits to several estates infested with Meadow Nematode, samples were taken from areas in which marigold was growing, and adjacent areas. Results (Table 2) show that marigold produced some reduction of Meadow Nematodes in all areas sampled.

TABLE 2.—*Comparison of numbers of Meadow Nematodes in tea with marigold and in adjacent areas without marigold*

Estate	Years marigold in tea	Meadow Nematode per 100 gm. soil	
		Tea with marigold	Tea without marigold
Ellamulle ..	2	7	77
	1	7	51
Ferham ..	1	19	30
Kirkoswald ..	8 months	8	13
Mt. Vernon ..	3	70	118

At Ellamulle and Ferham, the marigold was very thickly planted in the tea and the tea was in much better condition than adjacent tea. The above results are similar to those obtained by Visser and Vythilingam (1959).

A detailed experiment to follow up these observations is planned.

(d) **Chemicals to kill Meadow Nematodes in tea roots.**—As a result of successful preliminary experiments using organic phosphate insecticides, a pot test was set up to compare the effect of the following chemicals in eliminating Meadow Nematodes from the roots of basket plants: American Cyanamid compound 18-133, parathion, Virginia-Carolina Corp. compound VC-13, and Nemagon.

(e) **Survey for distribution of Meadow Nematode.**—GENERAL SURVEY.—This continues to show results similar to those reported in 1959, with high populations occurring only above 3500-4000 ft. Mapping with pins has been continued.

2. **SETTING OUT INFESTED PLANTS.**—Basket plants infested with Meadow Nematode have been set out in jungle areas at 8 elevations, ranging from near sea level to above 7000 feet, to determine whether or not the nematodes will decline or die at lower elevations.

(f) Survey of measures being used by estates to bring back infested tea into good bearing.—In the course of visiting estates infested with Meadow Nematode, Superintendents were asked what measures they were taking for the rehabilitation of infested areas, and how effective they considered these measures to have been. Of 20 estates visited, 9 were using specific practices in infested areas. These can be considered under three headings:

1. KEEPING A MAXIMUM AMOUNT OF FOLIAGE TO FEED THE ROOTS:
 - (a) resting bushes for periods up to one year,
 - (b) increasing pruning cycle,
 - (c) light prune,
 - (d) late, high tipping,
 - (e) light plucking during at least the first part of the cycle.
2. STIMULATING NEW ROOT GROWTH:
 - (a) splitting the manure application from 3 to as many as 6 times.
 - (b) composting; either by envelope forking or in pits, in amounts ranging from 20-40 tons per acre per year.
 - (c) forking in depth and frequency depending on rainfall.
3. PREVENTING SOIL EROSION:
 - (a) encouraging ground covers such as *Drymaria* or *Oxalis*.
 - (b) planting marigold (may also decrease Meadow Nematode).

Two estates reported that composting had been obviously effective; two that marigold had been effective, and one that splitting the manure application had been effective.

(g) Importance of other nematodes associated with tea.—1. ROOT-KNOT NEMATODES.—A test was initiated to determine the age at which the tea plant ceases to be susceptible to *Meloidogyne javanica*. Plants ranging in age from 3 to 10 months were set out in an infested plot and are being examined at intervals. A test to determine a host more suitable than tea for the growth and multiplication of the root-knot nematode of mature tea, *M. brevicauda*, was initiated. Six plants (snap bean, soybean, cucumber, cabbage, tomato and pepper) are being tested as hosts.

2. SPIRAL NEMATODES.—Identifications by Dr S. A. Sher at the University of California indicate that the two species of spiral nematodes commonly present around tea roots are *Helicotylenchus nannus* and *Scutellonema brachyurus*. They are found in practically every sample, but large numbers have not been particularly associated with declining tea. Experiments to determine whether or not they multiply on tea are continuing. A large series of collections of spiral nematodes have been made from tea and from jungle for use in Dr Sher's studies.

3. PIN NEMATODES.—The pin nematode commonly found around roots of tea has been identified by Dr A. C. Tarjan of the Citrus Experiment Station in Florida as *Paratylenchus curvitata*. The other species thought to have been a *Paratylenchus* appears to be a species of *Rotylenchulus*. However, mature females have not yet been found, so that an identification cannot be made at this time. Experiments to determine whether or not *P. curvitata* will multiply on tea are continuing.

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REPORT OF THE PLANT PATHOLOGIST FOR 1960

D. Mulder, Nat. Phil. Dr

General.—Staff—From 5th April till July 1st I was on overseas leave. Mr R. L. de Silva, Research Assistant, left for the U.K. at the end of August to start his post-graduate work at the Imperial College, London, aided by a Colombo Plan grant. Mr U. L. M. de Silva left after three months of training, at the end of June, to start work as assistant to Dr. Joachim in the low country. Mr P. V. Arulpragasam was appointed technical assistant and started work on January 1st.

A new Technical Assistant, Mr J. P. Herath, was appointed but could not begin work in 1960 because of shortage of accommodation.

Blister Blight.—An attempt was made to estimate the efficiency in terms of blister-blight infection of spraying copper by means of portable motorised mist-blowers. Fields on St. Coombs sprayed with knapsack sprayers and with mist-blowers under the control of the Superintendent were compared for Blister Blight. The mist-blowers gave better results than the knapsack sprayers, in July and August 1960, but the results were not fairly comparable in that the time after pruning was one year for mist-blowers and 2-3 years for knapsack sprayers.

Timing of Spraying.—No further developments have occurred in connection with the timing of spraying according to sunshine records. Because of the fact that leaf-wetness is also a critical factor, a surface-wetness recorder was bought and comparison of the records with those of a sunshine recorder and with the percentage blister-blight infection was started.

New Fungicides.—A fungicide trial in which various new fungicides were compared gave the following results (*see also Fig. 1*).

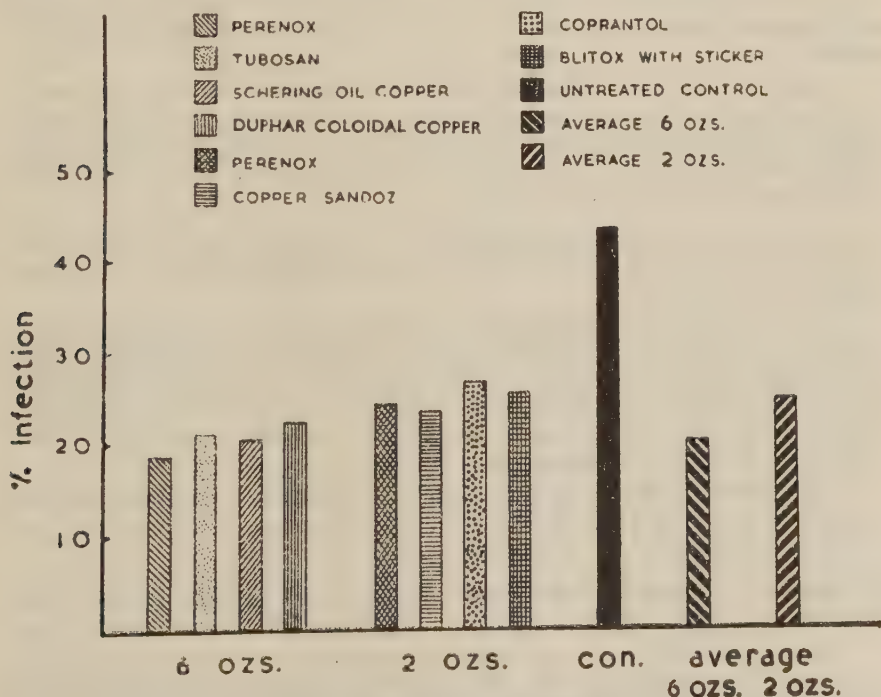


Fig. 1.—Comparison of blister-blight infection rates after spraying various fungicides at two area-dosages, in ounces per acre.

1. Tubosan (a mixed copper-sulphate zinc-carbamate fungicide), Duphar colloidal copper, Schering oil copper and Perenox all gave approximately the same results at 6-ounces and Perenox, copper Sandoz, Coprantol and Blitox did equally well at the 2-ounce level, the differences not being significant if compared with the unsprayed control. The average infection over the year of the treatments varied between 18.5% and 26%. The control had an average of 43.5% and the economic level is usually taken as 35%.

2. There was no significant difference between 6-ounce and 2-ounce treatments. This does not necessarily mean that estates could reduce their dosage to 2 oz. With these small plots of only 200 bushes each, and with the work continuously closely supervised, the distribution of the copper fungicide is likely to be much more uniform than it would normally be in estate practice. Trials on whole fields by unsupervised labour are necessary before estate practice can be altered. On the other hand to compare fungicides or sprayers experimentally, the work must be done very carefully and uniformly and the dosage must be reduced to a level at which substantial infection will occur, so as to show up differences. That level is not above 2 ounces of copper per acre. The possibility of an adverse effect of the use of a sticker on valuation of the tea was investigated in two subsequent trials. The Technologist reported that no taint was noticeable in samples sprayed with Tenac sticker.

Maintenance-leaf Fall.—Various fungi were isolated from leaves and branches originating from bushes with severe maintenance-leaf fall in the low country around Ratnapura. One culture was identified in Holland by the Central Bureau voor Schimmelcultures as being *Botryodiplodia theobromae*. This fungus is known to cause a root disease but can also, under moist conditions, grow up in the bush.

So far the fungus *Rhizoctonia solani*, which causes Black Rot of tea leaves and to which maintenance-leaf fall was earlier attributed, has not been found. An experiment was started on the control of maintenance-leaf fall by copper sprays.

Estimations of potash and starch in leaves and roots have shown that low potash and starch figures may accompany maintenance-leaf fall. There is reason to suppose that these conditions are the cause (potash) and result (starch) of maintenance-leaf fall. This disease may further cause severe dieback after pruning and eventually kill the bush.

Poria Control.—The experiments on control of *Poria* by D-D. fumigation at Dunsinane Estate, carried out partly by the estate and partly by T.R.I., have yielded interesting results.

Infected roots which were dug up from fumigated plots and placed in glass jars invariably became covered by a dense growth of the saprophytic fungus *Trichoderma viride*. Experiments in vitro with *Poria* and *Trichoderma* on nutrient agar and in soil showed the antagonistic action of *Trichoderma* on *Poria*. There is reason to suppose that *Trichoderma* plays a part in the control of *Poria* in the soil after fumigation.

Definite results about the possibility of eradication of *Poria* by means of fumigation cannot be expected before tea has been grown for about two years on the treated plots.

Virology.—Very little was achieved during this year on the subject of virus diseases.

The material infected with phloem necrosis virus which was taken to Neuchatel V.P. Sub-station was removed from there after showing completely healthy new growth and planted out at Eskdale Estate. So far no symptoms of phloem necrosis have been seen on new growth there.

The fauna of leaf-hoppers in tea fields has been investigated by Mr. Cranham in connection with the transmission of the phloem necrosis virus.

Bacteriology.—In Guatemala grass a bacterial disease was discovered. The symptoms are initially yellow stripes which start at some place where the leaf has been damaged, in many cases along the edge near the top. Later the yellowish spot develops downwards along the leaf in between the margin and the midrib leaving behind it a broad strip of dead tissue. If one cuts out a yellow piece of leaf tissue and puts it under the microscope, the bacteria are seen oozing out in great clouds. The bacterium has been cultivated and sent abroad for identification.

Only well-fed Guatemala grass is badly affected by this disease. If the grass shows symptoms of nitrogen deficiency (general yellowish colour of all leaves) then this disease can seldom be found. This high susceptibility of Guatemala grass that is well supplied with nitrogen is very probably due to a relative shortage of potash.

Nutrient deficiency symptoms in tea.—Attempts to cure symptoms of magnesium deficiency by spraying a mixture of a copper fungicide and magnesium sulphate have so far not been successful.

In order to make sure that a pink colour found on the youngest leaves is due to nitrogen deficiency and not to mechanical damage of the leaves, an experiment was laid down, in co-operation with Physiology Division, which proved the point.

In a series of plants grown in pure peat soil, a marginal chlorosis appeared in the top leaves, accompanied by some marginal necrosis. The cause is probably a side effect of the urea spray that was given to these plants.

In Guatemala Grass.—Apart from the nitrogen deficiency already mentioned above, phosphate and magnesium deficiency symptoms were identified by colorimetric determination of these elements in the leaves.

1. Phosphate deficiency shows up as the usual purple colour along the leaf margin. This symptom especially develops early after planting because at that time the root development is still very limited and shallow. Later on these same plants may show completely normal growth.

2. Magnesium deficiency was also found to occur at St. Coombs in a field recently planted with Guatemala grass.

The symptom initially consists of longitudinal yellow stripes. Later a kind of blotching or mottling of the remaining chlorophyll takes place so that a large part of the leaf becomes mottled. This symptom is completely in conformity with the standard symptom of magnesium deficiency in cereals and grasses.

Apart from these identified symptoms, a finer mottle occurs in some plants of Guatemala grass. The cause of this symptom is not yet known.

Diseases of shade trees and cover crops. — *Crotalaria anagyroides*.—On two estates *Crotalaria* was found to be attacked by the fungus *Parodiella grammodes* (Kze) Cke. This fungus grows in the leaves and covers them with black dots containing the perithecia. The result can be a severe reduction of growth.

Gliricidia.—On various estates at elevation above 4,500 ft. where the culture of *Gliricidia* is marginal, this plant shows symptoms of a gradual reduction of growth leading to stunting of shoots and dwarfing of leaves. The

leaves show a chlorosis and some deformation. The cause of this trouble is suspected to be a virus, a nutritional trouble being unlikely because of the occurrence of healthy and diseased shoots on the same plant.

Acacia decurrens.—The dieback of *Acacia decurrens* continued to be a problem for many up-country estates. The relation with lopping is not clear, although various Superintendents claim that the dieback is particularly severe after lopping.

The suppositions made in the course of time as to the cause of this condition are as follows:—

1. Too severe lopping during a drought results in dieback and death because the roots are devoid of starch.

2. During a wet period the roots are “drowned” in the wet soil, for lack of oxygen.

3. *Acacia* trees can be affected by a drought period to such an extent that much later, during a wet period, they die.

4. A fungus may grow from the pruning wounds down in the wood and finally block most of the water transport (considerable discolouration has been found in the wood of the stem).

5. Boron deficiency may occur as in *Grevillea* trees.

Investigations to reveal the true cause have started. It appears likely that gummosis, dieback, and death of *Acacia decurrens* is a physiological disease due to adverse weather conditions and less favourable soil conditions. Care should be taken not to lop during a drought period. If possible, drainage of the soil should be improved. In order to reduce the effects of lopping, frequent light loppings are advisable instead of heavy loppings at longer intervals.

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REPORT OF THE PLANT PHYSIOLOGIST FOR 1960

T. Visser, Dr Ir

1. **General.**—Mr N. Jayasundera left the Department in December in order to take up a post in the planting industry.

Altogether 250 letters were received and 275 despatched and a total of 65 visits were made by the combined staff; most of the letters were written and the visits made in connection with experimental work on sub-stations and estates.

2. **Field Experiments.**—2.1 **Plucking-level Experiment** (St. Coombs).—This replicated experiment—normal, dome and periphery plucking—was reported in detail in last year's Annual Report (Visser, 1960) giving the results of the first 70 plucks. The trial was continued for 20 plucks more, but "periphery plucking" was abandoned as the bushes had formed a closed canopy by that time, rendering the plucking of the periphery under the plucking table unpractical. This treatment was thereafter "normally plucked" (shoots above the plucking table broken back); "dome plucking" (no breaking back, producing a more or less dome-shaped bush) was continued. The results of the last 20 plucks—after which the experiment was discontinued—are given in Table 1.

TABLE 1—*The effects of different plucking methods on yield in lb. tea per acre*

Plucks	Normal plucking	Dome plucking	Periphery, changed to normal plucking
70—80	340 (100)	284 (83.5)	321 (94.4)
81—90	329 (100)	268 (81.5)	328 (99.7)
Total for 90 plucks	3212 (100)	2812 (87.6)	3473 (108.1)

These confirm the observations made on the preceding 70 plucks, namely the tendency of the yield to drop progressively with time after pruning when no breaking back is carried out, leading to a total loss of 400 lb. of tea. Breaking back appears to be a necessary procedure, probably because it provides a stimulus to new growth and because it prevents a reduction in light intensity in the surface of the plucking table. Observations by Major D. B. G. M. Roc of Ferham estate indicate that shaping the bush in advance by wedge-pruning and/or tipping (topiary) in combination with normal plucking (with breaking back) afterwards, may have possibilities.

Plucking below the table along the periphery—giving a yield increase of 260 lb.—had apparently no adverse after-effects. This plucking method may be both useful and profitable, but should only be applied in relatively densely planted fields.

2.2 **New fish-leaf-plucking Experiment (St. Coombs).**—The results over the first 4-year cycle have been previously described in detail (Visser, 1960). The plots were subsequently pruned in September 1959 and the observations continued until July 1960 in order to see whether the different plucking treatments had had any adverse after-effects, as judged by tipping weights and by the yield over the first 14 plucks. The treatments were the following (each at two manuring levels):

- (a) SSSS — single-leaf plucking throughout ;
- (b) SSFF — 1st and 2nd year single-leaf plucking, followed by fish-leaf plucking until pruning ;
- (c) SFFF/R — 1st year single-leaf plucking, then fish-leaf plucking, followed by 6 months resting before pruning ;
- (d) SFFF/S — as (c), but at the end of the cycle 6 months single-leaf plucking instead of resting.

The subsequent results following pruning are given in Table 2.

TABLE 2—*Tipping weights after pruning and yields over the first 14 plucks (all treatments single-leaf plucking) following different plucking treatments in the previous cycle.*

Dry weights in lb./acre	SSSS	SSFF	SFFF/R	SFFF/S	Sig. difference at P=0.05
Tippings	568 (100)	614 (108)	553 (97)	602 (106)	57
Yield	536 (100)	510 (95)	514 (96)	526 (98)	not sign.
Total	1104 (100)	1124 (102)	1067 (97)	1128 (102)	not sign

It will be seen from Table 2 that neither tipping weights nor yields of plots fish-leaf plucked for part of the cycle were significantly different from those of the control (single-leaf plucked throughout). Apparently, limited fish-leaf plucking of bushes in a good condition—as was the case in our trial—can be done with profit and without appreciable subsequent harm. However, it should be stressed again that fish-leaf plucking of fields which are not in an optimal condition for one reason or the other—vacancies, diseases, pests etc.—is not recommended.

2.3 **Spacing Experiment (St. Coombs).**—A trial comprising three different planting distances on two clones was laid down in No. 1 Field of St. Coombs estate. Unfortunately, more than half of the plants of one clone (777), having become eelworm infested in the nursery, succumbed later in the year, so that the trial had to be discontinued. There may have been some effect of planting distance on the mortality rate, which in March 1961 amounted to 42, 31 and 29% for the close, medium and wide spacing respectively.

2.4 **Pre-prune Experiment (Gonakelle Estate, Passara).**—The experiment at this location was fully described in last year's Annual Report (Visser, 1960), its main purpose is to test two types of pre-pruning—side-prune and half-prune—against established pruning methods in different seasons. The experiment has not yet reached the stage at which conclusions can be drawn.

2.5 **Pre-prune Experiment (Hantane).**—This experiment has been initiated in 1960 and is a replica of that at Passara.

2.6 **Cultivation-cum-pruning Experiment (Downside).**—A 2⁵ factorial experiment was laid down in 1956; the first cycle (of 126 plucks) was completed in June, 1960.

The following treatments were compared :

- (a) trenching in alternate rows and between every 2 alternate tea bushes (T) versus no trenching (NT) ;
- (b) deep forking in of manure (F) versus broadcasting (NF) ;
- (c) manuring twice per year (2M) versus once per year (1M) ;
- (d) manuring at a high ratio of 12 lb. N (12N) and at a moderate replacement ratio of 8 lb. N (8N) to every 100 lb. made tea ;
- (e) normal pruning (NP) versus side-pruning (SP).

The results over the first 3½-year cycle have been presented in Table 3.

TABLE 3—*Average annual yields in lb. made tea per acre of different cultivation and pruning treatments*

T —1165	F —1161	2M—1156	12N—1151	NP—1136
NT—1148	NF—1151	1M— 1157	8N—1161	SP —1176

It will be seen from Table 3 that none of the treatments has affected yield as yet. Only side-pruning had a significant effect in the 1st year after pruning, increasing the yield by 11%, but had no effect in subsequent years. It cannot be said at this stage whether the treatments compared do not differ essentially in their effects or whether a limiting factor—such as the presence of shade—blankets possible differences. The experiment has been transferred to the Agricultural Chemistry Division.

2.7 **Weedicide Trial (Langdale Division).**—A small-scale trial was laid down in tea pruned in May 1960, in which Simazine and Casoron (products of Fisons and Philips-Roxane respectively) were tested. Plots of 0.01 acre were clean weeded and treated on 7th July 1960; each of the 7 treatments (*see* Table 4) was duplicated (in blocks). Weed growth was assessed by removing and weighing all weeds per plot on 27th October and 30th December 1960.

TABLE 4—*Dry weights of weeds in lb. per acre following different weedicide treatments (July 1960)*

1 Treatments (50% wettable powder in 100 gallons per acre)		2 3 Weed weights	
		October 1960	December 1960
Untreated		1489 (100)	1872 (100)
Simazine	4 lb.	391 (26)	880 (47)
	6 „	258 (17)	742 (40)
	8 „	125 (8)	476 (25)
Casoron	10 lb.	876 (57)	1149 (61)
	20 „	379 (25)	896 (48)
	40 „	183 (12)	668 (36)

It will be seen from Table 4 that the lowest concentration of Simazine had suppressed weed growth much more than that of Casoron; the highest concentrations of both chemicals gave about equal weed suppression 3½ months after spraying (Column 2). Both weedicides appeared to have had considerable after-effects, as weed growth of the sprayed plots 6 months after spraying was still much lower than that of the control (Column 3).

On the whole, Simazine was somewhat more effective than Casoron, particularly when compared weight for weight. The weedicides also differed as regards their influence on specific weeds. Whereas Simazine initially suppressed all weeds except *Oxalis*, Casoron particularly suppressed *Oxalis*, but had less effect on *Drymaria*. With respect to tea, spraying with Simazine had no influence; the two highest concentrations of Casoron delayed recovery to some extent, but had otherwise no adverse effects.

3. Experiments on Clones: 3.1. Manuring of clonal plants.—Two trials were planned by us and carried out upon the initiative of the Colombo Commercial Company by the Superintendents of Dickwella and Spring Valley estates. A comparison was made between two soluble inorganic mixtures (a & b) and an organic mixture (c)—animal meal + Epsom salts. These mixtures contained.

	N%	P ₂ O ₅ %	K ₂ O%	MgO%
(a)	5.83	8.40	4.00	2.67
(b)	8.75	6.30	8.40	4.00
(c)	5.83	8.33	4.17	2.67

The plants (in baskets) were treated at both elevations in the same way and were manured every 2, 4 and 6 weeks respectively at the rate of 4 oz. per 100 plants for mixtures (a) and (c)—which contain the same amounts of nutrients—and at 2½ oz. per 100 plants for mixture (b) giving the same rate of nitrogen as with the other two mixtures.

A number of 2 x 100 plants was assessed 12-16 months after the (duplicated) treatments started. The assessments, substantiated previous findings (Visser, Kehl & Tillekeratne, 1958), and demonstrated again the marked effectiveness of manuring on young plants; the manured plants had developed approximately twice as many leaves as unmanured plants at both locations.

There were no great differences between the mixtures used; they all improved plant growth in about the same measure. Manuring at decreasing intervals (6—2 weeks) had little influence on growth on the one estate, but significantly increased growth on the other, probably due to differences in fertility and/or buffering properties of the soils used for basketing.

The application of a *soluble inorganic mixture* in nurseries is to be recommended, as it has the advantage that it is simpler and cheaper to apply than an insoluble inorganic (like T. 175) or organic (like animal meal or sterameal) mixture, while being equally effective.

3.2 Polythene bags versus baskets.—Having found in a small-scale trial that plants in polythene bags grew better than in baskets, a subsequent assessment was made of plants in polythene bags and baskets which were propagated in the nurseries of St. Coombs and Dickwella Estates; of each treatment 100 plants were chosen at random. It appeared at both locations that plants in polythene bags had grown significantly better than those in baskets, and in particular root development was favoured by the polythene bags; on an average the total weight of a plant in polythene was 18% more than that of a plant in a basket.

On account of the better growth obtainable and other advantages, the use of polythene bags instead of baskets in nurseries is recommended.

3.3 Propagation of tea by flush shoots.—A new propagation method has been tried by Mr F. H. Kehl in which *flush shoots* were used for propagation. The flush shoots, consisting of two leaves and a bud, were obtained from bushes in plucking and compared with normal single-node cuttings. They were planted in wooden boxes, which were placed in a chamber, the relative humidity of which was kept at about 80% by means of a (controlled) fine water spray.

The preliminary trial was carried out with cuttings from clones 2024 and 2025 (20 of each per treatment).

TABLE 5—*The rooting of flush shoots in comparison with that of single-node cuttings 12 weeks after planting*

Type of cutting	No. of cuttings	No. rooted	No. of deaths
Single node	40	22	13
Flush shoots	40	17	15

It appears from the results summarised in Table 5 that the flush shoots rooted nearly as well as the normal cuttings. The outcome of this trial was biased by the great number of deaths due to excessive dampness; it might have been better with a lower humidity and better soil drainage.

The results obtained suggest that any type of tea cutting will develop a root system if it can be kept active under suitable conditions for a sufficient length of time.

3.4 Root and shoot growth of young plants.—Two trials were carried out on young clonal plants to investigate the interdependence of root and shoot growth.

In the first trial (at the Hantane sub-station), plants of TRI 2024 and 2025—about 6 months established in beds—were cut across, removing about 3/5th of the top. The plants were thereafter fortnightly assessed (3 times 7-10 plants per clone at a time).

It was found that the weight of the roots initially decreased; they started to gain in weight at the same time that the top started to form new leaves—3 weeks after the cutting operation—but it took 4 weeks more before the roots had reached their initial weight. Apparently, the partial removal of stem and leaves caused a portion of the roots to die and this loss was made good only after the top had produced additional leaves.

In the second trial (at the Passara sub-station) 9-month-old basket plants of clone TRI 2024 were transferred into beds after having been treated as follows: (a) 1/4th of the top removed; (b) 1/3rd of the roots removed; (c) 1/4th of the top and 1/3rd of the roots removed; (d) plants untreated (control). The plants (7 times 10 per treatment) were assessed 15 months later.

It appeared that the removal of 1/4th of the top had resulted in a depression in plant weight by one quarter as compared with the control, irrespective of whether or not a portion of the roots were removed at the time of transplanting. In other words, the partial removal of the stem and leaves notably

depressed subsequent growth, while the partial removal of only the roots had no significant influence. It is possible that the absence of any effect of root removal is due to the fact that all plants lost roots anyway because of the transplanting operation.

Both trials clearly demonstrate that the partial removal of the top of the plant causes a considerable and persistent set-back of its growth. This may be unavoidable where it is necessary to form a frame, but it is evident that it should be restricted to a minimum.

The results suggest that any removal of stem and leaves should be done neither too shortly before or after transplanting nor at the time of trans-planting: probably not later than 6 weeks before or not earlier than 6 weeks after transplanting.

3.5 Shade Experiment.—This trial was initiated in 1958 in order to test the growth of young tea plants at various light intensities and different altitudes. The light intensities—obtained with plastic gauze screen (saran)—were 42%, 62% and 69% of daylight (and not as previously reported by Visser (1959)—40, 55 and 75%); full daylight served as a control.

The trial was carried out at Neuchatel (50 ft.), Passara (3300 ft.), St. Coombs (4500 ft.), and Pedro estate (6000 ft.). Each treatment (at each location) was carried out on clones TRI 2024 and 2025 and replicated twice. The experiment was concluded in May 1960, and the final results confirmed those noted previously (Visser, 1960). The main trends were as follows.

(a) Plant weights and leaf areas notably increased with increasing light intensity at the two middle altitudes. The increase was less marked at the lowest altitude, probably due to insufficient manuring, while plant weights and leaf areas were about the same at the highest altitude probably because strong winds were a disturbing factor.

(b) Top/root ratios were not significantly affected by the prevailing light intensity nor was there an evident effect of altitude.

(c) The average size of the individual leaves decreased both with increasing light intensity and increasing altitude (decreasing temperature). The average dry-matter percentage of the leaves was affected neither by light intensity nor by altitude.

(d) The average leaf area to leaf weight ratio (cm^2 leaf area/gram leaf weight) linearly decreased with the logarithm of the light intensity and linearly increased with the logarithm of temperature (altitude). This indicates that the leaves, apart from becoming smaller, also become thicker.

(e) The average net assimilation rate—of the order of 100-150 mg/100 cm^2 leaf area/week—linearly increased with the logarithm of the light intensity at all 4 altitudes.

4. Pollination, identification and selection characteristics of clones

4.1 Flower biological experiments.—As there is no information available in Ceylon on crossing techniques with tea, some preliminary trials were done on measures of protection against chance pollination, insect attractivity and self-incompatibility of tea flowers.

These trials were carried out on 5-year old clones growing in pots, each clone represented by 5 bushes. As the number of flowers available during the experimental period was relatively small, it was necessary to make use of several clones for any single trial. However, care was taken to have complete sets of all treatments on one single clone. The shoots to be used were labelled and

all the smaller buds and open flowers were removed; flower clusters were thinned to only one bud, leaving the biggest. Even so, some of the buds chosen still took 2 to 3 weeks before they were ready for treatment (about 1 day before opening). In two trials the individual buds on the same branch were marked with woollen threads of a different colour indicating different treatments.

Pollination was carried out by putting the pollen on the pistils with a small paint brush. Fresh pollen was collected 1-3 days beforehand and kept in a desiccator at 40% relative humidity at room temperature, under which conditions it remained viable for at least one week; in a refrigerator it can be kept viable for several months (Visser & Tillekeratne, 1958). Viability of the pollen was checked by germinating it in a 10% sugar solution.

In the first trial, different methods of "bagging" were compared with unprotected flowers, the pistils of half the number of which were covered with lanolin; in all treatments both the stamens and the corolla were removed and the flowers subsequently cross-pollinated; the control consisted of untreated flowers which were left to chance-pollination (on clones DK 8, DK 33, DK 39, Ken 16/3 & 2148). Unfortunately it was not possible in this and the other trials to judge results by the harvest of seeds as the bushes were needed for other purposes, but an impression of the relative effect of the treatments can be gained from the fruit set recorded between 6 and 9 weeks after treatment.

TABLE 6—*Fruit set of cross-pollinated flowers (of which corolla+stamens were removed) differently protected against chance pollination-treatments carried out between 19/4 and 12/5/60*

TREATMENT	No. of shoots	No. of buds	Fruitlets present	
			20/5/60	24/6/60
Control (flowers not treated)	11	42	38 (90)	21 (50)
Not covered	11	42	30 (71)	16 (37)
Not covered, pistils with lanolin	13	54	33 (61)	13 (24)
Yellow plastic bags	11	52	21 (40)	5 (10)
White plastic bags	12	47	29 (62)	12 (26)
Yellow paper bags	11	50	35 (70)	21 (42)
White paper bags	11	49	36 (73)	13 (27)
Muslin bags	11	50	43 (86)	23 (46)

It appears from the average results presented in Table 6 that by the end of June the flowers after having been protected by (transparent) plastic had set 17%, after paper bags 34% or after having remained uncovered 30%; flowers in muslin bags had set 46%.

Possibly, differences in temperature and humidity within the bags may have been responsible for the differences in fruit set. On the whole, the untreated flowers set better than most of the treatments, which is probably more an effect of the "bagging" method, than due to the removal of the corolla and stamens, as Wellensiek (1938) found that the latter treatment did not adversely affect tea-seed production.

The depressing effect of the lanolin treatment is in accordance with observations on other plants (Visser, 1955). It appeared from a second trial that the covering of the pistils of buds (only the corolla of which was

removed) with vaseline instead of with lanolin was less successful as only 7% fruit set was recorded 6-9 weeks after pollination as compared with 17% for buds treated with lanolin.

It would save labour and time if the bagging of buds of which the corolla and/or stamens are removed were not necessary. In that case, one must be fairly certain that flowers so treated are no longer attractive to insects. Similarly, time would also be saved, if it were sufficient to remove the corolla only, leaving the stamens. However, this could be done only if the tea (clone) were self-incompatible. Although the stamens do not usually release pollen just before the bud opens, contamination of the brush used for cross-pollination cannot be entirely ruled out, nor is it impossible that some of the flower's own pollen may not come on to the pistils afterwards.

With these considerations in mind two other trials were carried out, one on the insect attractivity of tea flowers (on clones D1, DK14 and TRI 2117) and one in which self-pollination and cross-pollination were compared (on clones D1, DK14, TRI 2117, TRI 2024 and TRI 2025).

TABLE 7—*Insect attractivity as measured by the fruit set of buds of which certain floral organs were removed (between 20/4 & 12/5)*

TREATMENTS	No. of shoots	No. of flowers	Fruitlets present on	
			20/5	24/6
Flowers intact	22	67	56 (84)	31 (46)
Corolla removed	22	75	64 (85)	31 (41)
Stamens removed	22	76	55 (72)	25 (33)
Corolla + stamens removed	22	74	62 (84)	17 (23)

TABLE 8—*Effect of self- and cross-pollination on fruit set of buds of which corolla + stamens were removed and protected against chance-pollination (pollinated between 23/4 and 10/5)*

TREATMENTS	No. of shoots	No. of flowers	Fruitlets present on	
			31/5	24/6
Self-pollinated	30	53	33 (62)	11 (21)
Cross-pollinated	42	100	68 (68)	19 (19)

Judging by the fruit set recorded 6-9 weeks after treatment (Table 7), flowers of which the corolla and/or stamens were removed appear to be still to a greater or lesser extent attractive to insects. This was also confirmed by visual observation, though visits to treated flowers were much less frequent. These results are contrary to those obtained by Wellensiek (1938) on tea flowers who found that 41% of flowers without stamens were pollinated as compared with only 3% of flowers without the corolla. For apples it has been found that of flowers of which stamens + corolla, corolla only, and stamen only were removed and of untreated flowers about 1%, 4%, 10% and 16% respectively formed fruits (Visser, 1955).

It will be seen from Table 8 that the percentage fruit set of self-pollinated and cross-pollinated flowers recorded 6-9 weeks after pollination was about the same. This result, too, is contrary to previous findings of Wellensiek (1938), who recorded a 4% fruit set for self-pollinated and a fruit set of 20% for cross-pollinated flowers 4-7 weeks after pollination.

Summing up our preliminary trials, it would appear that muslin bags or transparent paper bags are the most effective methods with respect to fruit set. However, the use of bags necessitates the removal of both stamens and corolla and the frequent removal and re-fastening of the bags as the buds of a shoot open at different times. Covering the pistils with lanolin will probably lower the fruit set, but is nevertheless much more efficient as only the corolla has to be removed and no bags are needed, making it possible to treat many times more flowers in the same period.

In view of the fact that only the fruit set could be recorded and the fact that our results as regards self-incompatibility and insect attractivity do not bear out those of Wellensiek, further information on these points would be desirable.

4.2 Phloem index investigations.—These were carried out, with the assistance of Mr K. L. D. Amaratunga, to use the *phloem index*—number of calcium oxalate crystals in the phloem of the leaf petiole—as a characteristic for clonal identification. This investigation has been concluded; the main results can be summarised as follows:

- (a) the phloem index markedly increases from the base to the apex of the leaf petiole and also increases with increasing leaf maturity and light intensity;
- (b) the phloem index is not greatly affected by altitude;
- (c) the phloem index varies with the location of the bushes (at one elevation), from bush to bush (at one location), and within the bush (the P.I. of leaves from the centre is considerably higher than that of leaves from the periphery of the bush);
- (d) the phloem index is a genetical characteristic, which is however highly modifiable; it may vary between 20 and 200 crystals for different clones. Whether it can be used as one of the characteristics for clonal identification is doubtful.

4.3 Observations on leaves and flowers.—Also for clonal identification, preliminary observations were made on leaves and flowers. Great variation was observed in leaf shape, size, colour, venation, degree of serration, texture of leaves, the degree of opening of mature leaves, and the position of the leaves on the stem. Among others, length/width ratios may provide a measure of identification.

The number of stamens appeared to be quite constant for a given clone at one location but varied from location to location.

4.4 Phenogenetics of yield.—Many observations have been carried out over the past year on a great number of clones present in our clonal areas at St. Coombs in order to investigate which clonal characteristics are related to yield. A summary of our findings follows.

(a) *Primary shoot growth* (tipping weight) is significantly correlated with yield, but with a fair number of exceptions to the rule. These exceptions are partly explicable by the fact that the rate of recovery after pruning is inversely related to branch thickness.

(b) *Branching angle and branching ability*.—As judged by the degree of correlation it appears that bush area depends more on the ability of a clone to form side-shoots and their growth rate than on the inherent branching angle between main shoot and side-shoot.

(c) *Growth rate of crop shoots*.—Only a weak relationship appears to exist between the growth rate of individual crop shoots (no. of days needed for development) and yield capacity. It would seem that the rate of shoot growth varies more with climate than genetically.

(d) *Dormancy of crop shoots*.—Dormancy, as expressed by the percentage banji shoots, is only weakly (inversely) related to the yield of a clone. It varies with manurial treatment, shade and climate.

(e) *The weight of individual leaves of primary shoots or the weight of crop shoots*—are not directly related with yield. There are indications that crop shoot size may have an indirect influence on yield in so far as it affects the degree of self-shading in the plucking table: small and big jat clones having the same yield intensity (weight per unit area) have different shoot densities (number per unit area).

(f) *Bush area and yield* are significantly correlated, the correlation between yield and yield intensity (yield per unit area) is higher, while yield intensity and bush area are not correlated. These trends imply that the yield of a clone depends both on its bush area and density of the plucking table, but that the latter factor contributes more to yield than mere area.

(g) The *yield of the centre of the bush* is significantly correlated with both total yield and yield intensity, but not with bush area. This indicates that the “centre yield” reflects the yield intensity of the bush as a whole, but is independent of bush size. The latter means that the centre of a bush with a small (inherent) area does not necessarily yield more than the centre of a relatively large bush.

(h) *Total leaf area and yield of clones* are significantly correlated, though with the usual exception of some clones whose yield does not seem to bear much relation to their leaf area. It is probable that the relationship is disturbed by the “self-shading factor.” It appears, namely, that clones with equal yield but of different jat have a different leaf-area index (L.A.I. = ratio of leaf area to ground area). Clones of relatively small jat have a higher L.A.I. than relatively big jat clones: the former, because of more self-shading in the plucking table, need a greater leaf area than the latter in order to produce the same yield.

(i) *Pruning weights and yield* are very highly correlated; the determination of pruning weights is possibly the most reliable single criterion for selecting bushes on yield capacity.

(j) *Influence of environment*.—It appeared that low-yielding clones showed more variation with age after pruning, and are more modifiable by climate with respect to the growth rate and weight of crop shoots, banji production, and yield as such, than high-yielding clones. This phenomenon is probably partly based on the close connection between root growth and growth of the rest of the bush.

The centre of the bush, being the most vigorously growing part, is less subject to variation in yield because of climate than the periphery of the bush.

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REPORT ON THE SELECTION, PROPAGATION, AND TESTING OF CLONES FOR 1960

T. Visser, Dr Ir & F. H. Kehl

1. General

1.1 *Staff*.—In July Mr A. C. B. Pethiyagoda was transferred from Passara to the new mid-country station at Hantane, Kandy, and Mr D. D. Kroon succeeded him at Passara. Mr H. B. Ratnayake was transferred from Neuchatel to the new low-country station at Kottawa, Galle, early in May.

1.2 *Advisory*.—Altogether 189 letters were received and 308 letters sent out. Advisory visits numbering 39 were made; in addition 22 other visits were made in connection with the collection of clonal material from estates and their distribution to the various clonal-proving stations.

2. *Clonal-proving Stations—Miscellaneous information*.—Apart from the work referred to under separate headings, the following is to be reported.

2.1 *St. Coombs*.—The uprooting of several acres of No. 8 field was begun at the end of 1959 and was completed in February, 1960. The entire area was lined out (for clonal blocks) and planted in Guatemala grass by March 1960.

2.2 *Passara*.—A rainfall of 90.81 inches and a total of 169 wet days were recorded for the year. Except for Blister Blight, no other serious outbreaks of diseases or pests were noted during the year. A former patana area planted since 1959 in Guatemala grass was lined out for (replicated) clonal blocks.

2.3 *Hantane*.—A new clonal-proving station was established at Hantane estate (5 miles from Kandy).

Early in March the uprooting of about 4 acres of tea was started. A considerable amount of time was spent on the removal of great quantities of rocks and stones to increase the uniformity of the terrain for small-scale clonal testing. The area was subsequently lined out in plots and was planted with Guatemala grass by the end of July. The growth of the grass was rapid and the first cut was possible in November.

Work in the nursery was started in July, necessitating a great deal of terracing and filling up with suitable soil before the first batch of cuttings could be planted early in September. A total of 55,000 cuttings was planted for experimental purposes.

Building work on the office-cum-store-room and the water tank commenced during the latter part of the year. A motorable road up to the office from the estate road was completed.

The officer-in-charge was invited to visit 6 estates in connection with nurseries and made several other visits for the collection of clonal material. He also attended a meeting of the Kandy P.A.

Figures, compiled by the estate, indicate a rainfall of 108.26 inches and a total of 192 wet days.

2.4 Neuchatel.—Since the transfer of Mr H. B. Ratnayake to Kottawa at the beginning of May no officer was stationed at Neuchatel. The plucking and other experimental work were supervised by an officer either from St. Coombs or from Kottawa. It was decided to hand both the areas to the estate early in January, 1961.

During the year, over Rs. 14,000 was obtained from the sale of clonal material.

2.5 Kottawa.—A new clonal-proving station was opened on crown land near Kottawa (12 miles from Galle). This sub-station is under the administrative jurisdiction of the Low-country Adviser.

Considerable time and energy were spent by officers of St. Coombs in co-operation with the Low-country Adviser in opening up this area and the establishment of nurseries and the planting of cuttings for experimental purposes.

An area of about 4 acres was cleared, lined out in blocks for clonal testing, and planted in Guatemala grass by the middle of the year. The growth of the grass has been poor so far.

3. Observation on clonal areas

3.1 St. Coombs.—Five new clones were put out in test rows in the clonal plots for preliminary trials. The 53 clones that were planted in 1955/56 completed the first year of plucking of the 1st cycle. The average calculated yield of the block is 1075 lb. per acre. All clones were tested for quality towards the end of the year. Further tests are to be carried out in 1961. The calculated yields of the better clones are shown in Table 1.

TABLE 1—1955/56 clonal area. *Calculated yields for the first year of first cycle*

Clone	Origin	No. of bushes	Calculated yields lb/acre 1st Year
CW 21	Coombewood	37	1815
A 7/10	Carolina	29	1650
CB3B3	Brunswick	26	1500
EY/27	Somerset (Radella)	28	1420
DUN 7	Dunsinane	25	1405
MT 18	Balangoda	20	1405
NL 4/2	Neluwa	28	1405
UH 9/3	Uva Highlands	23	1385
NL 3/1	Neluwa	34	1370
NL 8/3	Neluwa	35	1355
TRI 2142	St. Coombs	21	1320
SJ 2/30	St. James	29	1320
A2/18	Carolina	29	1285
TRI 1446	St. Coombs	26	1270
DT 1	Drayton	35	1240
GR. W 19	Great Western	20	1240

The 1947 clonal block completed the third cycle of plucking. The calculated yields of the clones, referred to in the Annual Report for 1955, p. 40 (Portsmouth, Kehl & Piyasena, 1956) are shown in Table 2.

TABLE 2—1947 Clonal area. Calculated yields for the 3rd cycle

Clone TRI	No. of Plants	Calculated yields lb./acre			
		1st year	2nd year	3rd year	Mean
2024	31	4175	2607	4010	3597
2026		rested for taking cuttings			
2025	34	4043	3069	3960	3691
2046	28	3317	3036	2904	3086
2016	33	3630	2838	2954	3141
2043	26	3927	3069	3449	3482
2023	26	3317	2690	rested for taking cuttings	3004
2022	35	2723	1452	1535	1903
2021	10	858	578	1106	847

The drop in yield in the second year is probably due to the drought and severe monsoon conditions in 1959. The low yields of TRI 2021 can be attributed to the clone being very susceptible to Meadow Eelworm.

3.2 Passara.—64 clones are being test-plucked ; 18 completed one year of plucking and the rest 9 months of plucking. The yields of the better clones that completed 1 year's plucking are given in Table 3.

TABLE 3—Calculated yields for the first year of the first cycle

Clone	Origin	No. of bushes	Calculated yields lb./acre 1st year
TRI 2023	St. Coombs	60	1800
TRI 2026	"	60	1305
TRI 2025	"	59	1240
TRI 740	"	30	1040
MT/BG	Balangoda	60	1025
TRI 25	St. Coombs	30	940
TRI 2024	"	60	925

The average yield for the 1st year of 18 clones is 845 lb./acre.

The yields of the majority of 46 clones that completed 9 months of plucking are disappointing. Clones TRI 2043, TRI 2086, Ampitiakande, AMDCA 9/16, Gonakelle PD 14, Gowerakelle GW 5/30, Ouvahkellie OK4, Passara Group P2, P3, P5 and P29, Thotulagalla T2/2 appeared to be susceptible to drought and may not be suitable for areas subject to droughts.

3.3 Neuchatel.—The 1956 block completed the 2nd year of plucking. The yields of the better clones are given in Table 4.

TABLE 4—1956 Clonal area. Calculated yields for the first cycle

Clone	Origin	No. of bushes	Calculated yields lb./acre	
			1st year	2nd year
TRI 18	Galutara	80	1625	2450 (11 months)
TRI 2026	St. Coombs	117	1315	2140 (11 ")
TRI 2022	"	15	1130	1581 (11 ")
B 18	Balangoda	13	950	1470 (8 ")
ED 31	Ederapola (Mixed)	58	395	1981 (11 ")
ED 397	" "	44	440	1855 (10 ")

The 1957 clonal plantings completed 20 months of plucking. The yields of the better clones are given in Table 5.

TABLE 5.—1957 *Clonal planting. Calculated yields for 20 months*

Clone TRI	Origin	No. of bushes	Calculated yields lb./acre	
			1st year	2nd year
2023	St. Coombs	57	2085	1475
2025	"	54	1675	1190
2021	"	52	1550	1120
2026	"	56	1460	1260
2022	"	57	1420	945
2024	"	85	1270	815

3.4 *Enselwatte*.—The clones mentioned in the previous Annual Reports i.e. TRI 2023, TRI 2024, TRI 2025, TRI 2026, TRI 1114, and Ken 16/3 maintain their vigorous growth. TRI 2021 and TRI 1294 are also reported to be growing satisfactorily. The yield of the small block of TRI 2026 continues to be satisfactory. The yield from January to July is 1292 lb. green leaf, which on an acreage basis amounts to over 2500 lb. of made tea for 7 months.

4. Clonal selection work

4.1 *Compilation of data obtained in the past*.—A start has been made in compiling all the available information on the great number of clones tested (in single rows) in the past 15 or 20 years at St. Coombs. These data concern primarily the yield performance over one or more pruning cycles, any secondary observations on jat (crop-shoot size), spreading habit, shoot density, blister resistance etc. It is hoped that the tabulated data can be published in the course of 1961.

4.2 *Nursery testing of clones*.—Clones which appeared to be promising in preliminary trials either in test rows or test plots in estates, including St. Coombs, were selected for nursery tests on rooting capacity and growth. Between March and May about 50,000 cuttings of 65 clones, consisting of 15 TRI clones and 50 from 25 estates, were put out at St. Coombs and Passara. Cuttings of each clone at each station were examined at 7, 9, 11, 13 and 16 weeks after planting in order to assess the rate of rooting (rooting-index). These tests were repeated with the same clones and 10 others in September at both stations and also at Hantane and Kottawa.

4.3 *Testing of clones in replicated plots*.—Clones that root and grow satisfactorily in the nurseries at St. Coombs, Passara, Hantane and Kottawa will be finally tested in replicated plots in each of the four stations. Some 192 plots were laid out for this trial in each location (768 plots in total) to be planted with the selected clones during 1961.

5. Other trials

5.1 *Field Trials*.—Those on Guatemala grass carried out at Passara and Neuchatel were concluded early in 1960; the final results showed the same trends as those reported last year (Visser, 1960).

5.2 *Propagation of clones by flush shoots*.—(see Report of the Plant Physiologist for 1960). This new technique showed considerable promise and may be very useful, if found generally applicable, for speeding up the propagation of selected mother bushes.

6. *Acknowledgments*.—The co-operation of Superintendents of estates who have offered clonal material for our clonal trials is gratefully acknowledged. Our sincere thanks are also due to the Superintendents and assistants of Enselwatte, Gonakelle, Hantane, Neuchatel and St. Coombs estates for all their assistance.

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REPORT OF THE TECHNOLOGIST FOR 1960

E. L. Keegel

Staff.—Mr K. Sothisrihari resigned in August; his place is to be filled early in 1961. Mr D. Kirtisinghe, Research Assistant, left for the U. K. on a Colombo Plan Scholarship to study in the University of London. As a result of these changes the Division was left with only one technical assistant namely Mr L. S. Weragoda. I was on long leave from the 13th of June to 10th December.

Advisory.—Despite the shortage of staff, advisory work was maintained. Seventy visits were made to factories, and 647 samples examined, arising mostly from these visits.

Instant Tea.—The work on this project, which was begun in 1958 in collaboration with the Ceylon Institute of Scientific and Industrial Research, was resumed at St. Coombs. Factors affecting the quality and taste of the product were further investigated and it was found that, as in orthodox manufacture, a wide latitude was permissible in certain operations. Although a product up to the standard of normal tea was not obtained, the results have been most encouraging. It was recognisable as tea, but had a few deficiencies which may be made good by further experimentation. An Economic Committee was set up in June to examine the future prospects of instant tea.

Clonal Manufacture.—(a) The search for clones with outstanding properties goes on uninterruptedly at St. Coombs. Testing of 500 low-jat bushes was systematically carried out, of which a few have been shown to be very promising. The work is to be continued in 1961. Besides this, 53 estate clones planted in St. Coombs have been tested for quality; the tests will be repeated in 1961.

(b) Quality, in the Assam sense, has so far been thought to be associated with the theaflavin content of tea. Recent work, however, throws considerable doubt on the relationship being a simple one. It has been found, for instance, that when stem is manufactured separately, its theaflavin content is 20-50% higher than in the leaf. The higher theaflavin content is not accompanied, however, by any cup quality.

Clone TRI 25 grown in the low country (Palmgarden Estate) was manufactured at St. Coombs and compared with the same clone grown at St. Coombs. Although the teas were favourably reported on, the St. Coombs-grown sample, which had very good quality, had a theaflavin content below the average for normal St. Coombs leaf. However, the St. Coombs-grown sample had a higher theaflavin content than the Palmgarden-grown one.

The summary of four tasters' reports was as follows:—

	<i>Palmgarden</i>	<i>St. Coombs</i>
Infusion	Bright greenish	Bright coppery
Colour	light	light
Strength	fair	fair
Quality	fair	very good
Flavour	little	useful
Valuation	Rs. 2/25	Rs. 3/76

The results are most interesting in that the Palmgarden sample has some quality and flavour, when the clone was manufactured at St. Coombs. Another feature of interest is that whereas no differences were observed in colour and strength, the infusions were not the same. It was also noticed that the Palmgarden tea was blacker in appearance. It seems likely that by proper selection and under suitable conditions of manufacture, quality can be obtained from low-grown leaf.

(c) The availability of material from clone TRI 2024 in comparatively large quantities on various estates made it possible to carry out a manufacture on a commercial scale. Unfortunately, most of the leaf collected was somewhat immature and the test for quality was therefore not a fair one. The resultant tea did not come up to our expectations. Nevertheless, the following report from a leading London firm of brokers was very encouraging indeed:—
“Dry leaf very well made and of a high standard of appearance. Liquor of good quality, bright and pungent with very good colour and strength. Infused leaf tends to be a little green. If this standard of leaf and liquor could be maintained in invoice form we consider that such a tea would receive good competition from buyers and should sell very well.”

(d) Assistance was as usual given to estates in quality tests, 145 having been carried out. The following clones appear promising as regards quality and could be added to the list published in the Tea Quarterly, Vol. 30, (December, 1959) pages 140 and 141:—

Estate	Clone	Special Features
Beaumont	12/3	Very good strength and quality—very bright coppery infusion
	11/4	Similar to 12/3
	4B/19	Similar to 12/3
	14/3	Good quality, useful colour and strength and bright coppery infusion
Cannavarella	CV 4/B1	Bright red infusion. Useful quality with very good colour
Talankande	TK 70	Very useful all-round liquor. Infused leaf exceptionally bright and coppery
Waltrim	WT 26	Very good all-round tea with a bright infusion and flavour. (Manufactured at a time when flavour is usually not apparent—April)

Age from pruning—(Tea at 6000' elevation—Nuwara Eliya district). Studies on the effect of age from pruning were continued. The report on the results obtained in 1960 should be studied in conjunction with those published in the annual reports for 1954, 1958 and 1959.

The experiments in 1960 were confined to the comparison of teas from plots recovering from pruning and from much older leaf. The latter at 1.1.60 was 54 months from pruning and the difference in age between the two was 44 months.

For the first 4 months after the bushes were first plucked, the teas had worse quality than the control (older leaf), after which there was no significant difference in liquoring properties. Average difference in valuation was as follows:—

1-4 months after 1st plucking—14 cents lower than control									
5-8	“	“	“	“	4	“	“	“	“
9-12	“	“	“	“	3	“	“	“	“

The last two differences were not significant.

The results to date support the view previously held that once a bush attains normal growth after recovery from pruning (say 6 months after the *first plucking*) the resultant teas are not inferior to those from older bushes, except perhaps in flavour or during a period of very marked quality. The year 1960 was unfortunately not favourable enough for the development of these two characteristics to confirm the findings obtained in 1954.

Withering materials—(a) Tygan (Agents—Messrs Walker Sons & Co.). In view of the interest shown in this type of mesh, more trials were undertaken. This material was first introduced to the Institute in 1950 (the Annual Report for 1951 refers to the results).

The amount of material available at that time for the tests was sufficient for only seven double tats of commercial size. Accordingly these and seven other (hessian) tats were arranged alternately in one bank. In this way any errors arising from the effect of uneven air distribution were reduced to a minimum, and provided a comparison between the two materials.

The results as a whole indicated that there was no appreciable improvement in the wither by the use of Tygan, the difference being only about 1%. On the other hand, claims have been made by an estate using Tygan in a whole loft that a 10% lower percentage wither could be obtained with Tygan, all other conditions being equal, and that by spreading up to 25% more leaf on Tygan it was still possible to get a wither equivalent to that on hessian. The discrepancy in these results could probably be explained by:

- (i) the alternate arrangement of hessian and Tygan tats at the Institute, an arrangement which could have restricted the air flow to the Tygan tats;
- (ii) and the difference in spacing between the tats; at St. Coombs it was 4½" whilst on the estate in question it was 4", thus making conditions of withering less favourable for hessian in the latter.

In any case, Tygan merited further investigation and further trials were done, this time separate from hessian and in an experimental bank with 13 tats, spaced 5", and a total spreading area of approximately 600 square feet. It was confirmed once again that for normal rates of spreading, the difference in the rate of wither between hessian and Tygan was not enough to be of practical importance. However, when spreading is thick, in the region of 1 lb. per 10 sq. ft., a better wither on Tygan is more noticeable. From the results to date (subject to further confirmation) it could be estimated that under the latter conditions about 20% more leaf could be accommodated on Tygan without adversely affecting the wither.

It would appear from these observations that an important factor in assessing the relative merits of any particular material is the amount of air available. A bigger difference in the rate of withering between hessian and Tygan would probably be obtained with reduced air flow or a smaller tat spacing. Thicker spreading would also bring about bigger differences because of restriction of air flow over the hessian tats.

(b) **Nylon net.**—This material, imported by Mr Hans Van Starrex of 9, Glen Aber Place, Colombo 3, has a more open mesh when stretched than Tygan, having 4 perforations to the inch as against 14 for the latter. As a result, withering is quite definitely accelerated by its use.

For the same rate of spread as on hessian at 1 lb. per 10-12 square feet, a 6% lower percentage wither was obtained on the Nylon net. For thinner spreads the difference is smaller. It was possible to spread up to 50% more leaf than on hessian without a detrimental effect on the wither and to obtain uniform withers for a spreading rate of 1 lb. per 7 sq. ft.

The extent to which the withering period could be shortened by the use of materials with open mesh will depend on the time heated air is stopped, the degree of wither at the time artificial withering ceases, and outside conditions. However, experiments are in progress to obtain a rough indication of the comparative rates of wither.

In the light of these results, it would seem feasible and advantageous for estates contemplating an increase in withering accommodation to replace hessian with Nylon net or Tygan mesh rather than extend lofts. But an important point to note is that air flow should be increased at the same time to derive the maximum benefits from the use of such materials. The only factor against their adoption is the cost, which is 3-4 times the price of hessian, but even then the expenditure involved in replacement might eventually be found to be lower than the extension of a loft to provide the same withering accommodation with hessian tats.

The superior wearing properties of Nylon material have also to be taken into account. The Tygan mesh tats installed in St. Coombs 10 years ago show hardly any signs of wear; it is only fair to say, however, that they have not been in daily use. From the present condition of the tats, it would be reasonable to expect them to last another 5 years at least, in which case, the longer life of Tygan than hessian merits consideration.

As for Nylon net, it is too early to estimate its life but, being able to accommodate more leaf, it has an advantage over Tygan. Installing it, however, presents some difficulties. The material has to be fully stretched at the time of fixing it to the tat wires, and this imposes a severe strain on the framework. It would be necessary therefore to have tat posts reinforced to prevent any damage to them.

Removal of the leaf from Nylon net tats takes more time than with Tygan mesh, because of the larger perforations. There is a tendency for small leaf to be caught, but the amount is so insignificant that it is hardly worth bothering about.

(c) **Hessian treated with Flintkote Emulsion type 3.**—These trials which commenced in 1955 were concluded in 1960, after the Shell Company of Ceylon Ltd., who were carrying out tensile strength tests, had decided not to continue these tests. According to their findings, it was conclusively proved that the impregnation of hessian with a 25% solution of Flintkote type 3 reduced that deterioration considerably.

These investigations were conducted in St. Coombs factory and in another where a direct-fired heater was used for withering. When the tests were abandoned the condition of the tats was as follows:—

Factory (with D. F. heater):—

25% emulsion	— in good condition.
15% „	signs of fraying at edges but still appeared in good condition.
5% „	—slightly inferior to 15%.
Untreated	—badly frayed at edges.

St. Coombs.—None of the four tats showed signs of fraying, but the untreated one appeared to have stretched more than the others.

The untreated one is now beginning to show signs of wear and tear whilst the treated tats still appear to be in good condition. They are being retained for further observation.

Rolling.—Trials on an experimental scale of a new type of roller table were completed with very satisfactory results. It was primarily designed to suit the Keegel cone, and consists of only 4 short battens with a ridged shape, as shown in the accompanying photograph (Plate 1). The chief features, it will be noted, are the simplicity of the design, a very broad surround (which reduces throw-out to a minimum) and a wide open space between the cone and the battens (which offers no restriction to the circulation of leaf under pressure).

It remains to be seen whether this new type of table, which is quite different from any design in commercial use, would give the same performance on a commercial scale as that observed in an experimental roller. Tests are now contemplated on a 36" roller.

Miscellaneous.—(a) "Speedy" Moisture Tester.—This instrument uses an absorbent for determining the moisture content, which is directly read off a dial. It appears to have proved successful for grain.

Trials were conducted with numerous samples of tea with a wide range of moisture contents. Results revealed that the instrument was inaccurate for low moisture contents below 3%; readings obtained were approximately higher by 1-2%. For a range of 3 to 5%, the readings were within $\pm 0.5\%$. For higher moisture contents, the instrument gave lower readings and differences as much as 4% were recorded between readings and true moisture contents.

The instrument possesses the following drawbacks:—

1. The operation of determining the moisture content involves several processes and is messy.
2. The absorbent has an over-powering and offensive odour and reacts with the moisture absorbed to produce a gas, the smell of which persists for a considerable time especially in a closed room.
3. Errors arising from grinding the sample and mixing it with the absorbent are always present.

For these reasons and the unreliability of the instrument over a range of 2-7% it is not suitable for the determination of moisture in tea.

(b) Taint trials.—

D.D.T. emulsion—no taint.

"Schering" Oil Copper—no taint.

(c) Trials on 'Tenac' sticker.—14 manufactures were done to assess the effects of this compound on the liquoring properties of a tea. For the purpose of this experiment 3 treatments were examined on each occasion, besides the control (untreated); they were, sticker alone, sticker and copper, and copper alone. No significant differences were observed but the variation was wide.

Acknowledgments.—To all the tea tasters who have reported on experimental samples we extend our cordial thanks and wish to express our deep gratitude for the assistance they have given.



Plate 1.—Experimental roller table with new type of battens.

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General.—The laboratories of the Institute are situated at St. Coombs Estate, Talawakele, and letters and enquiries should be addressed to the Director, Tea Research Institute, Talawakele. Telegraphic address: Research, Talawakele. Telephone: Talawakele 44 (Private Exchange).

It is particularly requested that letters should not be addressed to officers by name. Specimens and other consignments sent by rail should be forwarded to Talawakele Station, c/o Messrs M. Y. Hemachandra & Co. Ltd., Forwarding Agents. Carriage should be pre-paid.

Low-country estates should address their correspondence and enquiries to the Low-Country Adviser, T.R.I., Planters' Club, Ratnapura.

Visitors' Days.—The second and last Wednesdays in each month have been set aside for Visitors' Days at St. Coombs Estate and also at the T.R.I. Sub-Station, Gonakelle Estate, Passara, when it is hoped that those interested will visit the station.

Guest House.—The house formerly used for guests is now an officer's residence and it is regretted that, for the time being, no Guest House facilities are available. Those visiting the Institute or the Estate on business, who are unable to arrange accommodation in the neighbourhood, should seek the help of the Director.

Publications.—The Tea Quarterly, Bulletins (New Series), Pamphlets, and Annual Reports, published by the Tea Research Institute will be sent free of charge to Superintendents of Ceylon tea estates over ten acres in extent and to estate agencies dealing with Ceylon tea, if they register their names with the Director, Tea Research Institute of Ceylon, St. Coombs, Talawakele.

Other persons can obtain the publications of the Institute on application to the Director, the post-free subscription being fifteen rupees per annum for persons resident in Ceylon or India and £1-5-0 for those resident elsewhere. Single numbers of *The Tea Quarterly* can be obtained for Rs. 2-50 or 4s. Indian cheques should have four annas added to cover commission.

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